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TABLE OF CONTENTS

Indriana Hidayah, Alvi Syahrina, Adhistya Erna Permanasari
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Abstract— Conventional face-to-face classrooms are still the main learning system applied in Indonesia. In assisting such conventional learning towards an optimal learning, formative evaluations are needed to monitor the progress of the class. This task can be very hard when the size of the class is large. Hence, this research attempted to create a classroom monitoring system based on student's data of Department of Electrical Engineering and Information Technology UGM. In order to achieve the goal, a student modeling using Case-Based Reasoning (CBR) was proposed. A generic student model based on jCOLIBRI 2.3 framework was developed. The model represented student's knowledge of a subject. The result showed that the system was able to store and retrieve student's data for suggestion of the current situation and formative evaluation for one of the subject in the Department.

Keywords- case-based reasoning; student modeling; jCOLIBRI

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Abstract— One of the significant objectives of software engineering community is to use effective and useful models for precise calculation of effort in software cost estimation. The existing techniques cannot handle the dataset having categorical variables efficiently including the commonly used analogy method. Also, the project attributes of cost estimation are measured in terms of linguistic values whose imprecision leads to confusion and ambiguity while explaining the process. There are no definite set of models which can efficiently handle the dataset having categorical variables and endure the major hindrances such as imprecision and uncertainty without taking the classical intervals and numeric value approaches. In this paper, a new approach based on fuzzy logic, linguistic quantifiers and analogy based reasoning is proposed to enhance the performance of the effort estimation in software projects dealing with numerical and categorical data. The performance of this proposed method illustrates that there is a realistic validation of the results while using historical heterogeneous dataset. The results were analyzed using the Mean Magnitude Relative Error (MMRE) and indicates that the proposed method can produce more explicable results than the methods which are in vogue

Keywords- cost estimation; analogy; fuzzy logic; linguistic values; effort estimation; heterogeneous dataset.

Dr. Mohammed Ali Tawfeeq
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Abstract — This paper presents a new intelligent algorithm that can solve the problems of finding the optimum solution in the state space among which the desired solution resides. The algorithm mimics the principles of bat sonar in finding its targets. The algorithm introduces three search approaches. The first search approach considers a single sonar unit (SSU) with a fixed beam length and a single starting point. In this approach, although the results converge toward the optimum fitness, it is not guaranteed to find the global optimum solution especially for complex problems; it is satisfied with finding "acceptably good" solutions to these problems. The second approach considers multisonar units (MSU) working in parallel in the same state space. Each unit has its own starting point and tries to find the optimum solution. In this approach the probability that the algorithm converges toward the optimum solution is significantly increased. It is found that this approach is suitable for complex functions and for problems of wide state space. In the third approach, a single sonar unit with a moment (SSM) is used in order to handle the problem of convergence toward a local optimum rather than a global optimum. The momentum term is added to the length of the transmitted beams. This will give the chance to find the best fitness in a wider range within the state space. The algorithm is also tested for the case in which there is more than one target value within the interval range such as trigonometric or periodic functions. The algorithm shows high performance in solving such problems. In this paper a comparison between the proposed algorithm and genetic algorithm (GA) has been made. It showed that both of the algorithms can catch approximately the optimum solutions for all of the testbed functions except for the function that has a local minimum, in which the proposed algorithm's result is much better than that of the GA algorithm. On the other hand, the comparison showed that the required execution time to obtain the optimum solution using the proposed algorithm is much less than that of the GA algorithm.

Keywords- Bat sonar; Genetic Algorithm; Particle swarm optimization

4. Paper 30091229: PSO-Based Optimal Fuzzy Controller Design for Wastewater Treatment Process (pp. 20-29)

Full Text: PDF

Sawsan MorKos Gharghory, Computers and Systems Department, Electronics Research Institute, Dokki, Cairo, Egypt
Hanan Ahmed Kamal, Electronics and Communication Engineering Department, Cairo University, Giza, Egypt

Abstract—Fuzzy logic control (FLC) is a useful modeling tool that can handle the uncertainties and nonlinearities of modern control systems. However the main drawbacks of FLC methodologies is challenging for selecting the optimum tuning parameters. The set of parameters that can be altered to modify the controller performance are fuzzy rules and the parameters of membership functions for each input variable. In all cases, the correct choice of membership functions of the fuzzy sets plays an essential role in the performance of FLC. This paper proposes a method for finding the optimum membership function parameters of a fuzzy system using particle swarm optimization (PSO). As the set of nonlinear differential equations of an aerobic unit for wastewater treatment is a multivariable nonlinear problem, the combination of PSO and FLC named PSO-FLC controller is proposed for further improvements of the system response in both the transient and steady state response. To establish its efficiency, the proposed technique was employed to enhance the triangle membership functions of the fuzzy model of a nonlinear sludge activated system; the results show that the optimized membership functions (MFs) offered better performance than a fuzzy model with heuristically described MFs.

Keywords-component; PSO; FLC controller; Wastewater treatment process;

5. Paper 30091237: Anomaly Based Hybrid Intrusion Detection System for Identifying Network Traffic (pp. 30-35)

Full Text: PDF

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M. Hemalatha, Head, Department of Computer Science, Karpagam University, Coimbatore, TN, India

Abstract — Network intrusion detection system attempts to detect attacks at the time of occurring or after they took place. Since it is reliable and produces less alarm rate but it fails to detect unusual or new attacks. In this paper we

propose a hybrid IDS by combining the anomaly based detection approaches like Packet Header Anomaly Detector (PHAD), Network Traffic Anomaly Detector (NETAD), Application Layer Anomaly Detection (ALAD) and Learning Rules for Anomaly Detection (LERAD). The hybrid IDS obtained is evaluated using the KDD Cup 99 traffic data and Tcpdump data (Real Time Data). The number of attacks detected by misuse based IDS is compared with the hybrid IDS obtained by combining anomaly and misuse based IDSs and shows that the hybrid IDS with ALAD and LERAD performs well by detecting 149 attacks out of 180 (83%) attacks after training on one week attack free traffic data.

Keywords - Intrusion detection; Snort, Packet Header Anomaly Detection (PHAD); Network Traffic Anomaly Detector (NETAD); Application Layer Anomaly Detector (ALAD); Learning Rules for Anomaly Detection (LERAD); KDD Cup99 dataset and Real time traffic data.

Student Modeling using Case-Based Reasoning in Conventional Learning System

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***Abstract*— Conventional face-to-face classrooms are still the main learning system applied in Indonesia. In assisting such conventional learning towards an optimal learning, formative evaluations are needed to monitor the progress of the class. This task can be very hard when the size of the class is large. Hence, this research attempted to create a classroom monitoring system based on student's data of Department of Electrical Engineering and Information Technology UGM. In order to achieve the goal, a student modeling using Case-Based Reasoning (CBR) was proposed. A generic student model based on jCOLIBRI 2.3 framework was developed. The model represented student's knowledge of a subject. The result showed that the system was able to store and retrieve student's data for suggestion of the current situation and formative evaluation for one of the subject in the Department.**

Keywords- case-based reasoning; student modeling; jCOLIBRI

I. INTRODUCTION

Every classroom learning process has its own challenges. These challenges are often different depending on many factors. One possible cause is the composition of the attendants which has different backgrounds. Furthermore, having too many students in the class often make the teaching, learning, and evaluation process very hard. Yet, classroom monitoring is indeed very important to be done to ensure that students will successfully pass a course, hence, a monitoring system is required.

A model of effective instruction was written by Slavin (1995). The model is called QAIT model that consists of Quality, Appropriateness, Incentive, and Time [1]. Quality refers to the quality of instruction. Incentive refers to the degree to which the teacher makes sure that the students are well-motivated to work on the task. Time refers to the degree to which students are given the right amount of time to learn the material [1]. However the model's component that became the emphasis of this paper is Appropriateness which refers to the appropriateness level of instruction, which is the degree to which the teacher makes sure that the instruction is appropriate to the student's level of understanding. QAIT model suggests that a personal approach is needed to achieve an optimal learning result.

On the other hand, formative evaluation [2] is the evaluation process of an educational program while it is still in development, with the purpose of continually improving the program. Thus, implementing formative evaluation will optimize the learning result. However, the implementation will not be easy when the size of the class is large, i.e. consists of more than 70 students. To help the implementation of formative evaluation in a big classroom, Information technology can be used as a tool.

The determination of delivering education material that follows Slavin's Appropriateness criteria and ability to execute formative evaluation faces challenges when the size of the class is large. This paper proposed a framework on this problem by developing a student model using case-based reasoning technique. Based on individual student model, a classroom monitoring system can be performed and personalized recommendations were given to students as well as teachers to refine the learning process.

The rest of the paper is organized in the following way. The concept of student modeling is described in section II. Section III presents case-based reasoning method in general and jCOLIBRI as a framework based on CBR. Section IV describes the proposed framework. Result of the experiments and the analysis is presented in section V. Finally, Section VI concludes with a summary and a future plan.

II. STUDENT MODELING

Student Modeling (SM) is defined as the process of acquiring knowledge about the student in order to provide services, adaptive content and personalized instructional flow/s according to specific student's requirements [3]. Even though, student modeling techniques have been applied in many eLearning systems, the techniques are rarely used in conventional classrooms. Most SMs are built to support classroom learning that utilizes web-based learning or Intelligent Tutoring System (ITS). However fewer SMs are built to support face-to-face classroom learning.

Various techniques have been used to represent student models such as rules, fuzzy logic, Bayesian networks (BN), and case-based reasoning (CBR). Bayesian network is among

the most used techniques, thus, there are many resourceful researches. Previous work by Gonzalez, Burguillo and Llamas describes a qualitative comparison between SM using BN and CBR[4]. Generally BN is described as a complex technique that needs high computation and has a complex process in extracting knowledge, meanwhile CBR is said to have more advantages as it is easier to handle, renew and maintained. CBR based SM is proved to provide more evidence and reason when a student misconception happened. It also facilitates supervision of student by enabling the tutor to have a continuous view of student performance, including quantitative and qualitative information.

The result of this previous research became the foundation of choosing Case-Based Reasoning as a method to build a student model in this research.

III. Case-Based Reasoning

Case-Based Reasoning is a method to solve problem using solutions taken to solve previous problems [5]. This step is executed with the belief that the same problem will have the same solution. Rather than depending on the general knowledge of the problem or the relationship of the problem and the solution, CBR focuses more on using specific knowledge about the problem, situation and case that has been experienced.

CBR is a branch of artificial intelligence, where it is specifically related with automating reasoning using previous cases, problem definition for the current situation, and search of the previous problem and adapting the previous solution for a new problem. CBR is considered new to the field of problem-solving and machine learning.

CBR consists of four stages or known as 4R stage: Retrieve, Reuse, Revise and Retain. The cycle of the four stages is illustrated in Figure 1.

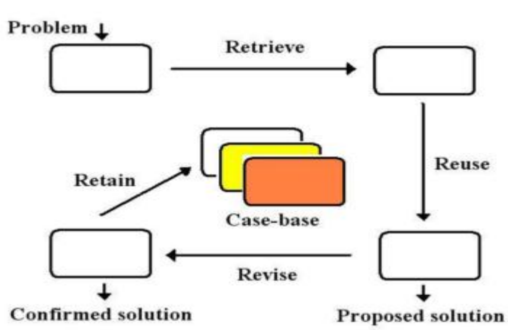

Figure 1. CBR Cycle [5]

The first stage is Retrieve. In this stage there is a process of extracting cases from one or a group of cases that is nearest to the new case. In computing the nearest case, the NN algorithm is used. The formula for NN is shown in (1).

$$similarity(T,S) = \frac{\sum_{i=1}^{n} f(T_i, S_i) x\, w_i}{w_i} \quad (1)$$

where T is the new case, S is the case in the case base, n is the number of attribute in every case, i is the individual case between 1 to n, f is the similarity function between case T and case S, and w is the weight assigned for i-th attribute that has value between $0 \leq w \leq 1$.

The second stage is Reuse where the solution of the previous case is reused to suggest solution to the new case. The third stage is Revise. In this stage, before storing the solution of the new case, the attributes' value of the case can be revised. Finally the last stage is Retain, where all of the information of the new case is stored in the case base.

jCOLIBRI

jCOLIBRI is an object oriented framework that is built to facilitate the design and implementation of a CBR system [6]. jCOLIBRI used Java programming language as a basis and JavaBeans for case representation. This framework is developed by an artificial intelligence group, GAIA, of University of Compultense, Madrid.

jCOLIBRI's main architecture consists of elements as follows:

1. Organization into three layers, persistence, core and presentation layers. Persistence is managed by connectors that access the persistence media and load the cases into different in-memory organizations. Core contains basic classes that has been previously defined.
2. Organization of the applications into precycle, cycle and postcyle. Moreover, new stages can be defined to be executed at different execution points. This add-on enables the development of maintenance or evaluation procedures.
3. Case structure consists of description, result, solution and justification.

IV. A Proposed Framework

The outcome of this research is a student model that is to be mapped into a system of case-based reasoning using jCOLIBRI as a tool. This system becomes the entity representation to evaluate case based reasoning of how effective it is to be a system for student modeling.

In this research a real classroom is selected where information such as student's data and course structure are learned. This information become the main materials to create a student model.

A. Student Model

After gathering information from a class, to represent the student's knowledge, a student model is created. This model is divided into components such as Student ID, cumulative GPA when the course is taken, grade of prerequisite courses, skills

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and/or experiences, competence that should be reached, exam or quiz result, and final grade. With Retrieval method using NN, the most similar previous case is obtained. Figure 2 shows the main tasks performed in the case-based reasoning technique to create the student model.

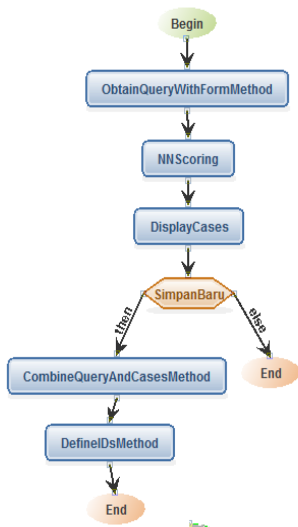


Figure 2. The tasks in CBR method in creating SM

Figure 3 illustrates the generic student model, where all of the components are stored in a case base of CBR system.

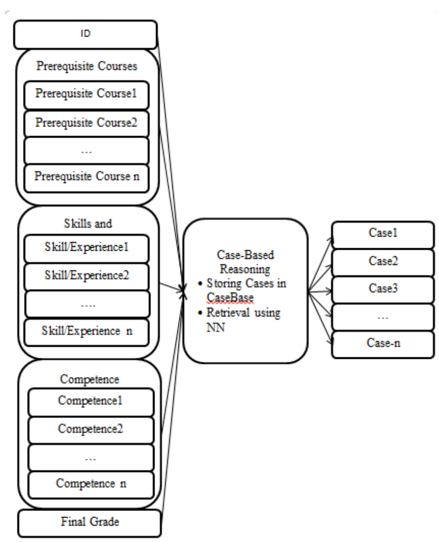


Figure 3. Student Model Representation

Student model that is specifically built for the Microprocessor System course has the component such as ID, GPA, grade of prerequisite course such as Digital Systems and Basic Programming, experiences and skill using assembly language and programming language, and designing an instrument. There are also quiz results, mid exam result and final grade of the course. These components became attributes of the cases that are organized into description, solution, result and justification.

After conducting this research, it is found that to get student's information from an "offline" class is harder than "online" class. The elements that are found in the offline class are only those that have numeric value in it, such as quiz or exam result in contrast to online class that can measure history or student's activity. In offline classes it is difficult to examine other things such as learning style.

B. 4R Stages

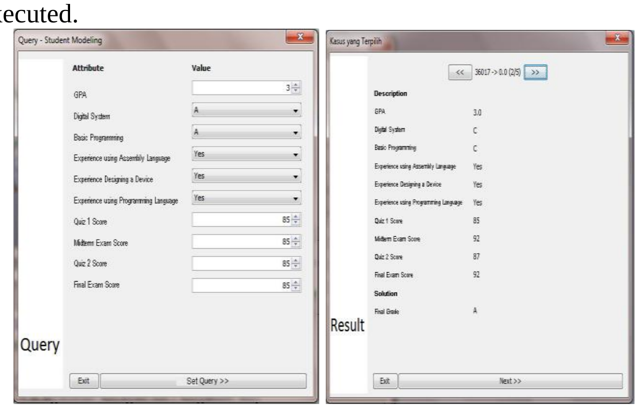
The 4R Stages of this system starts with the Retrieval stage where query of the new case is entered to find the similar cases. Figure 3a illustrates the query entry on the system. Users can enter value at the attribute field. From this query, NN scoring is used to find the most similar cases. These cases are shown in the Figure 3b.

Users can browse through these five most similar cases before choosing one from the five cases. By browsing through the cases, user can get some insight from the similar cases by observing their pattern. From the five cases users can choose one case where the attribute of the chosen case is reused, therefore the Reuse stage is conducted.

The third stage is the Revision stage. Here the components of the case are reviewed and the attributes are enabled to editing as shown in Figure 4a. If the new case has some differences to the selected case or some of the values needs to be updated, adjustments can be made in this stage.

Revision is also used to add more data into the case base if there is no case in the case base that is exactly the same with the new case. To add a new case into the case base a new ID needs to be defined.

The last stage is Retain. Retain is the activity where the new case is stored into the case base for future use as shown in Figure 4b. When the ID of the case is defined, either the same or new ID, the next button here is where the Retain stage is executed.



(a) (b)

Figure 4. Query Panel and Result Panel

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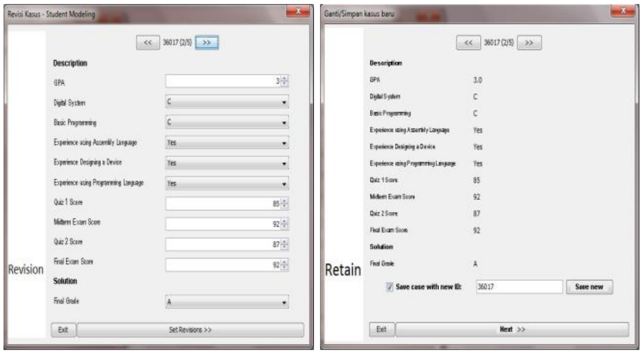

(a) (b)

Figure 5. Revision Panel

C. System Impact

To examine the impact of the system as a tool to support formative evaluation, the following test is conducted.

There is a set of information about a student but only up to his mid-exam score (‘UTS’). This student has a background with a good grade in his prerequisite courses but has low score on quiz and mid-exam.

After entering this data into the query, previous cases are obtained. There are four previous cases with the final grade of B and one previous case with A. It can be implied that there is a chance for this student to get good final grade. The case that has final grade of A shows significant change to the next quiz result and final exam. It means the student must do well in the next quiz and final exam. However if there is no significant change, like the other four results, most likely this student will get B.

V. ADVANTAGES AND DISADVANTAGES

There are many advantages of CBR that is found in this research. Firstly is its simple computation. CBR’s main computation is in its Retrieval stage on searching for the similar case. The rest activities in CBR only include storing and presenting data. Secondly, CBR do not look at any relation between the attributes. Some other SM techniques has relation between attributes and adds complexity to the system. Then CBR enables revision, which made the case base of the system stays updated.

However, some disadvantages are also found through this research. Firstly, the accuracy of the data depends on the case base. It means that all the data entered must be valid and the case base must stay updated. Secondly, one system can only be used for one course. The student model is general, but the system is specific to only one course. Other courses might have different attributes due to different teaching or different prerequisites.

jCOLIBRI as a framework also has many advantages and disadvantages that is found at the process of this research. The advantages of jCOLIBRI is that it uses Java, a language that is already common and have many IDE for programming. jCOLIBRI also have many previously written methods. However this can be the one of the drawbacks where system development depends on the availability of the method in the framework. For example, the data of the whole class cannot be observed because jCOLIBRI does not support to do so.

jCOLIBRI lacks in documentation. As a newly developed framework this is understandable. But there is no user forum, so there is no keeping track of those who use this framework for different purposes. This is seen as a major drawback in the programming field.

VI. CONCLUSION

In this research project, a student model has been made based on CBR by using jCOLIBRI framework. Several conclusions can be drawn as the following.

- jCOLIBRI can facilitate 4R of CBR well.
- In implementing a student model, both CBR and jCOLIBRI has its own advantages and drawbacks.
- The system can support formative evaluation in the course Microprocessor Systems by showing patterns of previous cases to the student as their feedback. However the system can only show the cases individually, not as a whole class data.
- This system can help student and lecturer in predicting their final grade, thus an improvement effort can be made accordingly.

Overall, some recommendations in implementing a system for student model in the future are listed below.

1. Teachers/lecturer must define clearly the structure of the lesson in advance. It must be clearly stated when they are going to take score (how many quiz and exams). The class must also have a complete documentation.
2. Complete data of student is needed prior to conducting the class.
3. The existing e-learning system can also be integrated here.
4. As jCOLIBRI has several drawbacks, the system can also be supported with other features outside the framework that are compatible.

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ESTIMATION OF EFFORT IN SOFTWARE COST ANALYSIS FOR HETEROGENOUS DATASET USING FUZZY ANALOGY

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***Abstract*— One of the significant objectives of software engineering community is to use effective and useful models for precise calculation of effort in software cost estimation. The existing techniques cannot handle the dataset having categorical variables efficiently including the commonly used analogy method. Also, the project attributes of cost estimation are measured in terms of linguistic values whose imprecision leads to confusion and ambiguity while explaining the process. There are no definite set of models which can efficiently handle the dataset having categorical variables and endure the major hindrances such as imprecision and uncertainty without taking the classical intervals and numeric value approaches. In this paper, a new approach based on fuzzy logic, linguistic quantifiers and analogy based reasoning is proposed to enhance the performance of the effort estimation in software projects dealing with numerical and categorical data. The performance of this proposed method illustrates that there is a realistic validation of the results while using historical heterogeneous dataset. The results were analyzed using the Mean Magnitude Relative Error (MMRE) and indicates that the proposed method can produce more explicable results than the methods which are in vogue**

Keywords- cost estimation; analogy; fuzzy logic; linguistic values; effort estimation; heterogeneous dataset.

I. INTRODUCTION

Software cost estimation has gained tremendous importance in the last two decades due to its imperative necessity for efficient effort estimation in software analysis. In general, effort estimation for software projects is categorized as algorithmic and non algorithmic models [1]. Algorithmic estimation deals with the application of mathematical computation method while Non algorithmic estimation is essentially based on machine learning techniques. Software cost estimation by analogy is one of the most conspicuous machine learning techniques and is basically a form of Case-Based Reasoning [2]. Estimation by analogy is based on the assumption that similar software projects have similar costs. However, the technique needs improvement especially while handling the categorical variables. Fuzzy logic cost estimation models [3] are more suitable for projects with indistinct and imprecise information. The advantage of this method is that it interprets the linguistic values very much similar to the human way of interpretation. However, this method is not able to overcome the imprecision and uncertainty problem in an efficient manner. The proposed method resourcefully estimates the software effort using Fuzzy analogy technique based on reasoning by analogy and fuzzy logic.

The paper is divided into 5 sections as follows. Section 2 discusses the related work. The key features of the Fuzzy Analogy approach are presented in section 3. In section 4, an explorative analysis is conducted for validating the proposed method and based on the results; a refined Fuzzy Analogy approach with the performance outcome is illustrated in section 5. The conclusion of the findings is dealt in Section 6.

II. RELATED WORK

Effort estimation during the initial stages of project development is invariably essential for the software industry to cope with the unrelenting and competitive demands of today's world. The estimation should also be accurate, reliable and precise to meet the growing demands of the industry. Keung [4] demonstrates that the estimation by analogy is a viable alternative to predict accuracy and flexibility where the prediction of effort is done by selecting a set of completed projects which are akin to the new projects. Hasan Al-Sakran [5] has highlighted that retrieval of similar projects from the dataset can be effectively done by an improved CBR integrated with different methods. Recently, a new method has been proposed [6] to improve Analogy based software estimation by conducting empirical experiments with tools such as ESTOR and ANGEL.

A new framework has been elucidated [7], based on fuzzy logic, for estimation of effort during the initial stage itself, especially for projects representing linguistic variables. A transparent and improved Fuzzy logic based framework [8] is proposed for effectively dealing with the imprecision and uncertainty problem. The Gaussian MFs [9] have been used in

the fuzzy framework, which show good results while handling the imprecision in inputs. The ability of this method to adapt itself to the varying environment in as much as its efficient handling of the inherent imprecision and uncertainty problem makes it a valid choice for representing fuzzy sets.

A multi agent system has been employed [10] to deal with the characteristics of the team members in a fuzzy system. Many studies have been carried out [11] which utilize the fuzzy systems to deal with the ambiguous and linguistic inputs of software cost estimation. In [12], it is noted that homogeneous dataset results in better and more accurate effort estimates while the irrelevant and disordered dataset results in lesser accuracy in effort estimation. Wei Lin Du et al. [13] proposed a methodology combining the neuro-fuzzy technique and SEER-SEM that can function with various algorithmic models.

III. PROPOSED WORK

A. *Analogy*

The basic idea of prediction of effort in cost estimation by analogy [14] is that projects having similar features such as size and complexity will be similar with respect to project effort. The method gains its importance since the estimate is based on actual project experience.

B. *Fuzzy Logic*

Fuzzy logic is based on the human behaviour and reasoning. It is similar to fuzzy set theory and used in cases where decision making is difficult. A Fuzzy set can be defined by assigning a value for an individual in the universe of discourse between the two boundaries that is represented by a membership function.

$$A = \int_{x} \mu_A(x)/x \qquad (1)$$

Where x is an element in X and $\mu_A(x)$ is a membership function. A Fuzzy set is represented by a membership function that has grades between the interval [0, 1] called grade membership function.

C. *Fuzzy Analogy*

Fuzzy analogy is the fuzzification of classical analogy procedure. It comprises of three steps. 1) Identification of cases 2) Retrieval of similar cases and 3) Case adaptation. Each step is the fuzzification of its equivalent classical analogy procedure.

1) Identification of cases: The main objective of Fuzzy analogy method is to effectively deal with the categorical data. In identification of cases, each project is indicated by a set of selected attributes which can be measured by numerical or categorical values. These values will be represented by fuzzy sets. In the case of numerical value x_0, its fuzzification will be done by the membership function which takes the value of 1 when x is equal to x_0 and 0 otherwise

For categorical values, it is supposed to have M attributes and for each attribute M_j, a measure with linguistic value is defined (A_k^j). Each linguistic value, A_k^j, is represented by a fuzzy set with a membership function ($\mu_{A_k^j}$). It is preferable that these fuzzy sets satisfy the normal condition. The use of fuzzy sets to represent categorical data, such as 'very low' and 'low', is similar to the way in which humans interpret these values and consequently it allows to deal with the vagueness, imprecision and uncertainty in the case identification step.

2) Retrieval of Cases: This step is based on the selection of software project similarity measure. In retrieval of cases, a set of candidate measures is proposed for selecting software project similarity. These measures assess the overall similarity of two projects P_1 and P_2, $d(P_1,P_2)$ by combining all the individual similarities of P_1 and P_2 associated with the various linguistic variables V_j describing the project P_1 and P_2, $d_{V_j}(P_1,P_2)$. After an axiomatic validation of some proposed candidate measures for the individual distances $d_{V_j}(P_1,P_2)$, two measures have been retained [15].

$$d_{V_j}(P_1,P_2) = \begin{cases} \max_k \min(\mu_{A_k^j}(P_1), \mu_{A_k^j}(P_2)) \\ \text{max–min aggregation} \\ \sum_k \mu_{A_k^j}(P_1) \times \mu_{A_k^j}(P_2) \\ \text{sum–product aggregation} \end{cases} \qquad (2)$$

Where A_k^j is the fuzzy set associated with V_j and $\mu_{A_k^j}$ which are the membership functions representing fuzzy sets A_k^j.

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$$\text{Effort} = A * (\text{SIZE})^{B+0.01*\sum_{i=1}^{N} d_i} * \prod \text{EM}_i \quad (3)$$

Where A and B are constants, d is the distance and EM effort multipliers. By using the above formula the effort is estimated.

3) Case Adaptation: The objective of this step is to derive an estimate for the new project by using the known effort values of similar projects. In the proposed method, all the projects in the data set are used to develop an estimate of the new project. Each historical project will contribute to the calculation of the effort of the new project according to its degree of similarity with this project.

IV. RESULTS AND DISCUSSION

The historical heterogeneous dataset used in this study is the Desharnais, Nasa 60 and Nasa 93 dataset published in PRedictOR Models in Software Engineering (PROMISE) [18]. The proposed work is implemented by using the default packages of JAVA Net beans. Table 1, summarizes the number of projects collected under each dataset with the actual average effort compared with the estimated average effort using fuzzy analogy method.

TABLE 1. COMPARISON OF ACTUAL AVG. EFFORT WITH ESTIMATED AVG.EFFORT.

Dataset	No. of Projects	No. of features	Actual Avg.Effort	Estimated Avg.Effort
Nasa60	60	2	406.413	359.324
Nasa93	93	2	734.031	530.148
Desharnais	77	2	5046.308	4786.311

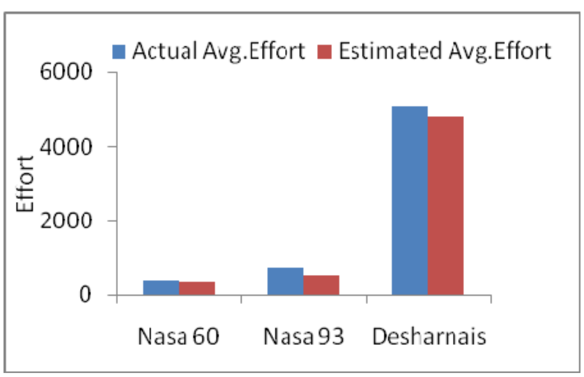

Figure.1. Comparison of Actual Avg Effort and Estimated Avg.Effort

Fig.1 indicates the comparative performance of actual average and estimated average effort for the 3 dataset.

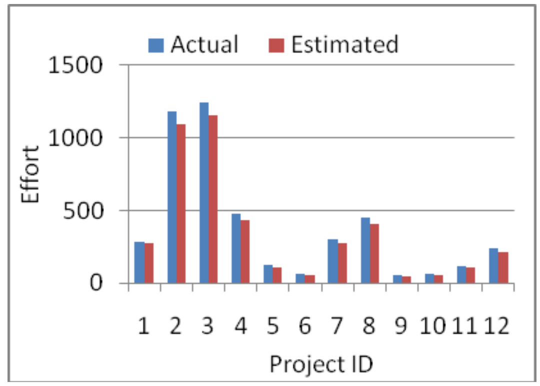

Figure.2. Comparative Results of actual and estimated effort with the Nasa 60 dataset

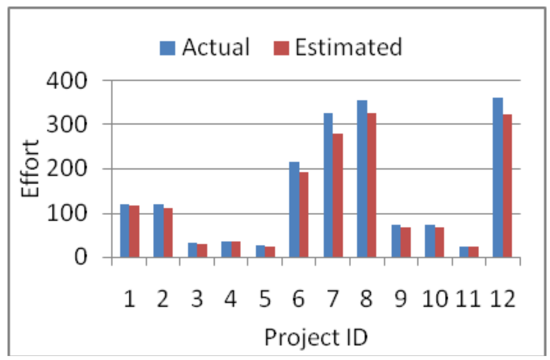

Figure.3. Comparative Results of actual and estimated effort with the Nasa 93 dataset

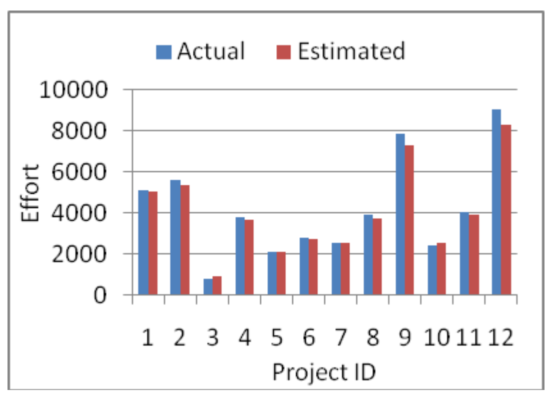

Figure.4. Comparative Results of actual and estimated effort with the Desharnais dataset

From Fig.2-4, it is inferred that the proposed method is very efficient with less effort value compared to the actual effort present in the existing three dataset.

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V. PERFORMANCE ANALYSIS

A common criterion for the evaluation of effort estimation models is the Mean Magnitude of relative Error (MMRE). The MRE and MMRE can be measured by employing the following formulae

$$MRE = \left| act_i - est_i \right| / act_i \quad (4)$$

$$MMRE(\%) = \frac{1}{n}\sum_{i=1}^{n} MRE * 100 \quad (5)$$

Where the act_i is the actual effort, est_i is the estimated effort and N is the no of cases. The comparison of proposed method with the existing method based on MMRE measure is tabulated in Table 2.

TABLE 2. COMPARISON OF MMRE IN PERCENTAGE WITH THE EXISTING METHODS.

Dataset	Nasa60	Nasa93	Desharnais
Proposed Method	5.15	6.95	4.98
Analogy with Fuzzy Number	33.37	28.55	26.89
Fuzzy method	32.651	54.81	30.6

The MMRE measure for Nasa 60,Nasa 93 and Desharnais dataset of the proposed method is compared to the existing method [3][16] [17].

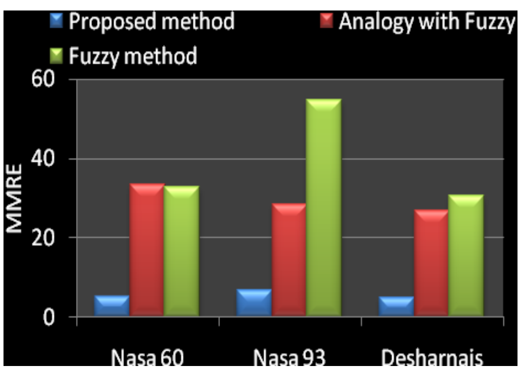

Figure.5. Comparison Performance of MMRE (%)

Fig.5 clearly depicts that the MMRE value for the heterogeneous dataset is very low compared to the different existing methods, thereby proving that the proposed method is very efficient.

VI. CONCLUSIONS

The existing techniques for estimation of effort in software cost analysis are not able to handle the categorical variables in as much as they could not overcome the imprecision and uncertainty problem in an efficient manner. Fuzzy analogy has been developed subsequently to address these issues. However, the results are not very effective while handling the categorical data and necessitate improvement. Fuzzy analogy based on reasoning by analogy, fuzzy logic and linguistic quantifiers has been utilized for enhancing the performance as well as to overcome the imprecision and uncertainty. In the proposed method, both categorical and numerical data are represented by fuzzy sets. The salient benefit of this method is that it can overcome the imprecision and uncertainty problem to a considerable extent while describing the software project. The results also clearly indicate that proposed method effectively estimates the effort for the historical heterogeneous project datasets.

However, the existing methods and present research work deals only with the project characteristics for effort estimation but the important attributes such as team characteristics have been neglected. Therefore, the future research warrants a pragmatic approach to include the team member characteristics to evaluate the project effort in a resourceful manner.

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Intelligent Algorithm for Optimum Solutions Based on the Principles of Bat Sonar

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***Abstract*— This paper presents a new intelligent algorithm that can solve the problems of finding the optimum solution in the state space among which the desired solution resides. The algorithm mimics the principles of bat sonar in finding its targets. The algorithm introduces three search approaches. The first search approach considers a single sonar unit (SSU) with a fixed beam length and a single starting point. In this approach, although the results converge toward the optimum fitness, it is not guaranteed to find the global optimum solution especially for complex problems; it is satisfied with finding "acceptably good" solutions to these problems. The second approach considers multisonar units (MSU) working in parallel in the same state space. Each unit has its own starting point and tries to find the optimum solution. In this approach the probability that the algorithm converges toward the optimum solution is significantly increased. It is found that this approach is suitable for complex functions and for problems of wide state space. In the third approach, a single sonar unit with a moment (SSM) is used in order to handle the problem of convergence toward a local optimum rather than a global optimum. The momentum term is added to the length of the transmitted beams. This will give the chance to find the best fitness in a wider range within the state space. The algorithm is also tested for the case in which there is more than one target value within the interval range such as trigonometric or periodic functions. The algorithm shows high performance in solving such problems. In this paper a comparison between the proposed algorithm and genetic algorithm (GA) has been made. It showed that both of the algorithms can catch approximately the optimum solutions for all of the testbed functions except for the function that has a local minimum, in which the proposed algorithm's result is much better than that of the GA algorithm. On the other hand, the comparison showed that the required execution time to obtain the optimum solution using the proposed algorithm is much less than that of the GA algorithm.**

Keywords- Bat sonar; Genetic Algorithm; Particle swarm optimization

I. INTRODUCTION

The basic concept of any optimizing problem is to identify the alternative means of a given objective and then to select the alternative that accomplishes the objective in the most efficient manner, subject to constraints on the means. The problem can be represented mathematically as,

$$\text{Optimize } y = f(x_1, x_2, \ldots, x_n) \quad (1)$$

$$\text{Subject to } g_i(x_1, x_2, \ldots, x_n) = \begin{Bmatrix} \le \\ = \\ \ge \end{Bmatrix} b_j \quad j = 1, 2, \ldots, m \quad (2)$$

Equation (1) is the objective function and (2) constitutes the set of constraints imposed on the solution. The $x_i (i = 1,2,\ldots, n)$ represent the set of decision variables, and $y=f(x_1, x_2, \ldots, x_n)$ is the objective function expressed in terms of these decision variables. Depending on the nature of the problem, the term optimize means either maximize or minimize the value of real function by systematically choosing input values from within an allowed set and computing the value of the function.

In general, optimization can be defined as the process of finding a best optimal solution for the problem under consideration.

Today, optimization comprises a wide variety of techniques. These techniques can be found in several literatures. Evolutionary computing may be the most prominent one in this field. In the 1950s and the 1960s several computer scientists independently studied evolutionary systems with the idea that evolution could be used as an optimization tool for engineering problems. The idea in all these systems was to evolve a population of candidate solutions to a given problem, using operators inspired by natural genetic variation and natural selection [1]. In 1975, Holland described how to apply the principles of natural evolution to optimization problems and built the first genetic algorithms (GA) [2]. In the last several years there have been widespread interaction among researchers studying various evolutionary computation methods, and the boundaries between GAs, evolution strategies, evolutionary programming, and other evolutionary approaches have broken down to some extent. These techniques are being increasingly widely applied to a variety of problems, ranging from practical applications in industry and commerce to leading-edge scientific research [3].

Particle swarm optimization (PSO) is another technique that optimizes a problem by iteratively trying to improve a candidate solution with regard to a given measure of quality. PSO is a form of swarm intelligence and is inspired by bird flocks, fish schooling and swarm of insects [2]. It is used as a

Dr. Mohammed Ali Tawfeeq

heuristic search method for the exploration of solution spaces of complex optimization problems. Development on the PSO technique over the last decade has been made by different researchers. The heuristic in PSO suffers from relatively long execution times as the update step needs to be repeated many thousands of iterations to converge the swarm on the global optimum. Soudan, B. and Saad, M. [4] explored two dynamic population size improvements for classical PSO with the aim of reducing execution time. The most attractive features of PSO are its algorithmic simplicity and fast convergence. However, PSO tends to suffer from premature convergence when applied to strongly multimodal optimization problems. Lu H., et al. [5] proposed a method of incorporating a real-valued mutation (RVM) operator into the PSO algorithms, aimed at enhancing global search capability. The PSO contains many control parameters. These parameters cause the performance of the searching ability to be significantly alternated. In order to analyze the dynamics of such PSO system rigorously, Tsujimoto, T. et al. [6] proposed a canonical deterministic PSO system which does not contain any stochastic factors, and its coordinate of the phase space is normalized. The found global best information influences the dynamics. They regarded this situation as the full-connection state. The authors try to clarify the effective parameters on the CD-PSO performance. Feng Chen, et al. [7] proposed an improved PSO by incorporating the sigmoid function into the velocity update equation of PSO to tackle some drawbacks of PSO in order to obtain better global optimization result and faster convergence speed.

PSO shares many common points with GA. Both algorithms start with a group of a randomly generated population; both have fitness values to evaluate the population, both update the population and search for the optimum with random techniques. However, unlike GA, PSO has no evolution operators such as crossover and mutation. On the other hand, it is important to mention in this introduction that GAs and PSO do not guarantee success [2], and some times are not guaranteed to find the global optimum solution to a problem. They are satisfied with finding acceptably solutions to the problem.

This paper introduces a new intelligent algorithm. The proposed algorithm is a problem solving technique that uses the principles of bat sonar as its model in searching the approximate optimum solution for the problems. The algorithm introduces three search approaches, a single search unit, multisearch units, and a single search unit with a momentum. Each of these approaches can approximately find the optimum solution in solving the required problem with a reasonable efficiency depending on the complexity of the problem and the number of optimum points that exist in the problem.

This paper is organized as follows; the next section describes the main proposed algorithm. Section 3 introduces more efficient search approaches. Section 4 contains the experimental results, while, section 5 presents the conclusion of this work.

II. MAIN ALGORITHM

The sonar of a bat is an active echolocation system. In addition to providing information about how far away a target is, bat sonar conveys information about the relative velocity of the target, the size of various features of the target, and the azimuth and elevation of the target [8].

In order to find its prey the bat may sit on a perch or fly around using its sonar signals. Some type of bats are considered as a 'high duty cycle' bat since it produces signals 80% of the time that it spends echolocating [9]. When a bat begins to echolocate it usually produces short millisecond long pulses of sonar, and listens to the returning echoes. If prey is detected by the bat, it will generally fly toward the source of the echo. The bat appears to be an amazing signal processing machine that has an accuracy of 99%. The way in which the bat can measure the distance and the size of its prey is as shown in Fig. 1 [10].

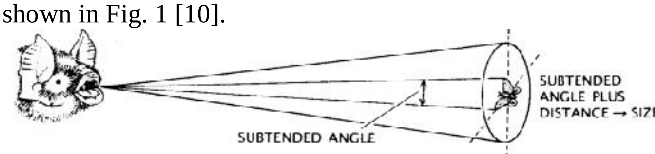

Fig. 1. Sonar signal of a bat

The proposed algorithm search for optimum solutions in problems depends mainly on these principles. In this algorithm, each and every point in the search space represents one possible solution. The sonar in this algorithm transmits several signals in different directions starting from a proposed starting point. Each transmitted signal contains a batch of N beams. These beams are of fixed length. The returned values (value of the fitness function at the end point of each beam) are checked with each other and compared with the starting point to determine the optimum one. If optimum point is detected, the sonar unit flies toward this point exchanging its starting point with the new one, then starts to transmit signals again from this point in different directions searching for better optimum solution. Otherwise, the sonar unit stays in its original starting point and retransmits signals in other directions. This process is repeated until the algorithm finds the best optimum solution.

Fig. 2 illustrates a sample on how the proposed algorithm searches for the optimum point. In this figure the sonar unit transmits beams of signals starting from point P1. The returned signals find better solution in P2. This causes the sonar to fly toward P2. This process is continued with P3, then with P4.

In this example, it is assumed that the entire returned signals to P4 are not fitter than P4, thus the algorithm considers P4 to be the optimum point.

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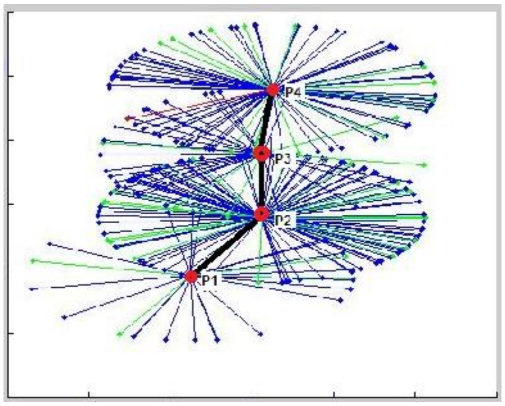

Fig. 2. Search process for optimum solution

The fitness function considered in the proposed algorithm, is the evaluation function that is used to determine the solution. This function can be n-dimensional. The optimal solution is the one with the best fitness function.

The main proposed algorithm in this paper considers a single sonar unit (SSU) flying in the state space searching for the optimum solution. This scenario represents the first search approach introduced in this work. The details of the algorithm are as follows:

Step 1. Initialize the following main parameters:

- Solution range: min, max values of the search space variables.
- Beam length L: random value not exceeding half the solution range:

$$L \le Rand * Solution\_range/2$$

- Number of beams N: Small integer random value representing the number of beams in each single transmitted signal.
- Starting point pos_s : any point in the search space selected randomly.
- Angle between beams θ: one of two techniques are assumed to be used in this algorithm. The first one is to randomly select a small fixed value θ between any two successive beams, while the other technique is to randomly select a different angle θ_i between any two successive beams, where (i=1, … , N-1). We called these two techniques "Fixed$_\theta$" and "Rand$_\theta$" respectively.

The above mentioned parameters are showed in Fig. 3.

Step 2. Evaluate the fitness function at the start point F_s.

Step 3. While stopping condition is false, do Steps 4-7.

Step 4. Select random value representing the main beam direction θ_m starting from pos_s.

Step 5. Transmit N beams starting from pos_s with main beam direction of θ_m and angle θ between any two successive beams.

Step 6. Determine the coordinates of the remote end point pos_i for each transmitted beam ($i=1,\ldots,N$), then evaluate the fitness function F_i at these ends. As an example, in a three dimension state space:

$$x_i = x_{pos_s} + L\cos(\theta_m + (i-1)\theta) \quad (3)$$

$$y_i = y_{pos_s} + L\sin(\theta_m + (i-1)\theta) \quad (4)$$

$$pos_i = [x_i, y_i]$$

$$F_i = f(x, y)$$

Step 7. Compare the fitness values;

If F_s is the optimum value (i.e., for maximizing $F_s \ge F_i$, and for minimizing $F_s \le F_i$) then go to step 3

Otherwise:

Replace the coordinates of pos_s with the coordinates of the optimum point of F_i and replace F_s with the optimum F_i:

$pos_s = pos_i$ of optimum F_i

F_s = optimum F_i,

then go to step 3

Step 8. Test for stopping condition: The algorithm can be terminated according to following stopping criteria:

- A fixed number of iterations have occurred.
- All solutions converge to the same value and no improvements in the fitness value are found.

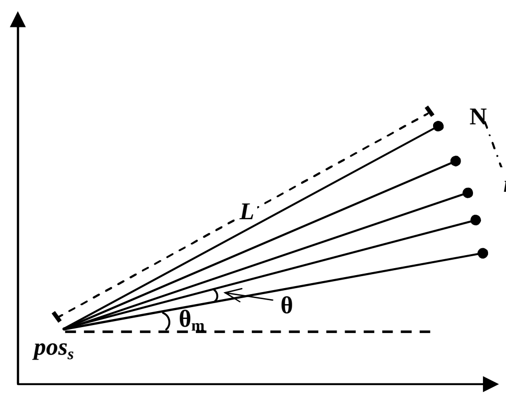

Fig. 3. Single batch of beams contained in a single transmitted signal

The algorithm is a kind of a parallel search; this comes from the fact that the technique used here is to check for several solutions at once. Over iterations, selection for best fitness leaves out bad solutions and gets the best in each step. Thus, the proposed algorithm tries to converge to optimal solutions.

In SSU, although the results converge toward the minimum or maximum fitness, it is not guaranteed to obtain the global optimum solution, especially in complex problems with wide state space. This leads to develop more efficient search approaches.

III. More Efficient Search

This paper introduces two other more efficient search approaches, in which, the first one uses multisonar search units, while the other one adds a momentum term to the beams length. The backbone of these two algorithms is the main algorithm of SSU approach mentioned previously.

A. Multisonar Search Units (MSU)

This approach considers multisonar units (*m*) search for the optimum solution/s at the same moment. Each sonar unit has its own starting point. These units are working in parallel in the same search space. For an example Fig. 4 shows an MSU with three sonar units. This approach can be used in solving more complex, large search space problems, and in problems that have several optimum values. Because of the parallelism nature of this approach, MSU can reduce the execution time needed to find the optimum solution considerably especially in problems with large state space.

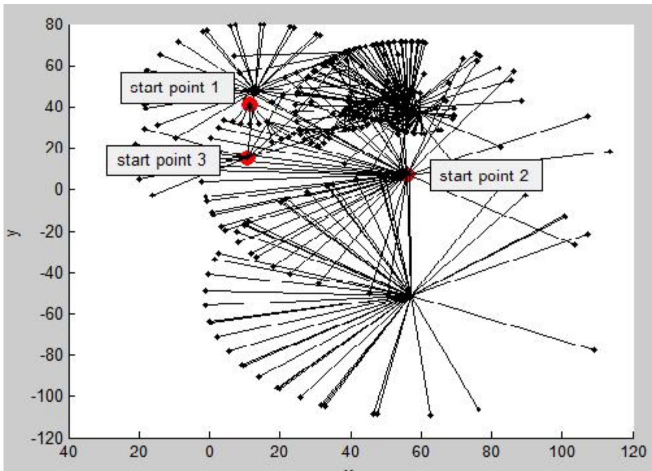

Fig. 4. MSU with three sonar units

B. Single Sonar Units with A Momentum (SSM)

Sometimes the solution found by SSU is not guaranteed to be the global optimum. This mainly comes from the nature of the problem and its state space, or due to the random selection of the initial parameters especially for the beam length. In such cases, the selected length of the transmitted beam, whatever the direction is, is either very long or very short so that it can not exceed to the area in which the solution is a global minima or maximum. SSM introduces a momentum term μ in order to reduce the problem of convergence toward a local optimum. In this approach, when the sonar unit converges toward an optimum solution, this solution will be checked again to be assured that it is not a local optimum. The proposed technique used here is to add a momentum term to the length of the transmitted beams. Using a momentum gives the chance to search for optimum solution in a wider range within the search space. The value of the momentum is considered to be within the range 0<μ<1. The new beam length then becomes:

$$L_{new} = L_{old}(1 \pm «) \qquad (5)$$

IV. EXPERIMENTAL RESULTS

Different types of fitness functions are used to test and evaluate the proposed algorithm with its three search approaches. In these tests, some of the initial parameters are considered to be the same. This will give the chance to make a worthy and meaningful comparison between the performances and the efficiencies of the three approaches. These parameters are:

Number of beams in each transmitted signal N=5

Angle between any two successive beams for Fixed$_\theta$ technique = π/12

Maximum number of iterations in each run = 100

Number of runs (epochs) = 500

The performance of each approach is considered to be the degree on how much the obtained solution meets the goal. Where the goal is assumed here as the value that is equal or approximately equal to the optimum solution. Thus, for each solved function, the overall performance ° for the used approach is determined as,

$$° = S_g / M \times 100\% \qquad (6)$$

Where, S_g is the number of the obtained solutions greater than or equal to the goal, and *M* is the total number of epochs. In this work two goal values are considered. The first one is assumed to be greater than 97.5% of the optimum solution, while the second one is greater than 96% of the optimum solution. The corresponding calculated performances for these goals are named $°_1$ and $°_2$ respectively.

And the overall efficiency ¦ is calculated as

$$¦ = AverageObtainedFitness / OptimumFitness \times 100\%$$

$$¦ = Avg(F_{obt}) / F_{opt} \times 100\% \qquad (7)$$

The average Euclidean distance $\|E_d\|$ between the obtained solutions and the optimum one are calculated as follows:

$$\| E_d \| = \frac{1}{M}\sqrt{\sum_{i=1}^{M}(F_{opt_i} - F_{obt_i})^2} \qquad (8)$$

Where,

F_{opt} is the fitness of the optimum solution,

F_{obt} is the fitness of the obtained solution using the proposed algorithm.

The used fitness functions and their tests results are as follows:

A. The first used function is a third order polynomial with a single variable. This function is described as

$$F_i = f_1(x) = x^3 - 5x^2 - 20x \qquad (9)$$

It is required to find the maximum value of this function within an assumed range of -6<x<6. The algebraic calculation shows that the maximum value of this function is about 15.4564 at x= -1.4064.

In this work, the SSU approach is tested to find the optimum fitness value. Fig. 5 shows one epoch as an example on how SSU search for the best fitness. The obtained results for the 500 epochs are summarized in table 1.

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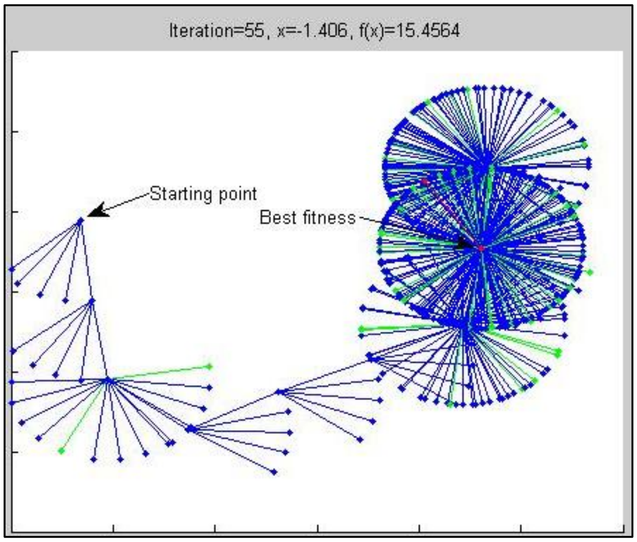

Fig. 5. SSU search for optimum fitness

TABLE 1
SUMMERY OF THE OBTAINED RESULTS OF f_1 USING SSU

Max obtained fitness	15.4564
x	-1.4064
Avg(F_{obt})	15.4294
Avg. no. of iterations	50.2
¦	99.8%
°$_1$	99.8%
°$_2$	100%
$\|\|E_d\|\|$	0.003

The results of this test show that the best obtained fitness matches the maximum calculated fitness with high efficiency. Fig. 6 shows the obtained solutions, in which each dot in this figure represents an obtained fitness. In this test most of the obtained values are very close to each other, and some of them are equal, thus they appear in this figure as overlapped dots.

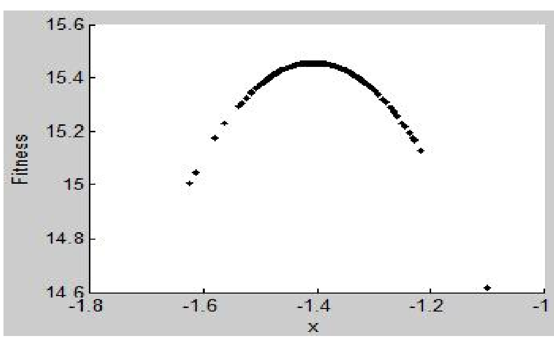

Fig. 6. Obtained solution of f_1 using SSU

Although the test results of using SSU are good, but it is not guaranteed to find the global optimum solution for complex problems with wide state space.

B. The second used function is a fifth order polynomial of a single variable described by (10). It is also required to find the max value of this function within the range of -6<x<6.

$$F_i = f_2(x) = x^5 - 10x^4 - 5.2x^3 - 12x^2 + 5.5x \quad (10)$$

The maximum calculated value of f_2 is 0.5635 at x= 0.1932. In this test, we first examined the following approaches: SSU, MSU with two sonar units, and MSU with three sonar units. Each approach tested using Fixed$_\theta$ and Rand$_\theta$ techniques respectively. The obtained results are summarized in table 2.

TABLE 2
SUMMERY OF THE OBTAINED RESULTS OF f_2 USING SSU AND MSU

	SSU		MSU (2 units)		MSU (3 units)	
	Fixed$_\theta$	Rand$_\theta$	Fixed$_\theta$	Rand$_\theta$	Fixed$_\theta$	Rand$_\theta$
Max(F_{obt})	0.5635	0.5635	0.5635	0.5635	0.5635	0.5635
x	0.1932	0.1932	0.1932	0.1932	0.1932	0.1932
Avg (F_{obt})	0.5560	0.5536	0.5587	0.5585	0.5625	0.5628
Avg. no. of iterations	53.3	54.7	51	53.7	53.7	56.7
¦	98.67	98.2%	99.1%	99.1%	99.82%	99.87%
°$_1$	85.2%	81.2	91%	93.8%	99.6%	99.8%
°$_2$	90.8%	90.4%	95.6%	95.8%	99.8%	100%
$\|\|E_d\|\|$	7×10^{-4}	1×10^{-3}	5×10^{-4}	1.2×10^{-3}	1.2×10^{-4}	7.9×10^{-5}

The obtained solutions of f_2 using MSU approach with three sonar units and Randθ technique are shown in the three parts of Fig. 7, in which, each part represents one search unit.

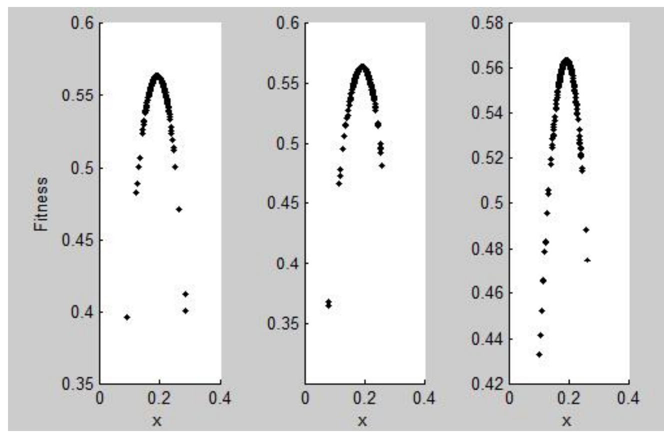

Fig. 7. Obtained solution of f_2 using MSU with three sonar units

The test of the SSU approach shows low performance. This performance can be improved by using the SSM approach, in which a momentum term μ is added to the length of the transmitted beams. By applying a momentum μ=0.9 and solving for f_2 using both Fixed$_\theta$ and Rand$_\theta$ techniques, the performance is significantly increased to be 100%, with much better Euclidean distance as shown in table 3.

TABLE 3
RESULTS OF f_2 USING SSU AND SSM

	SSU		SSM	
	Fixedθ	Randθ	Fixedθ	Randθ
Max(F_{obt})	0.5635	0.5635	0.5635	0.5635
x	0.1932	0.1932	0.1932	0.1932
Avg (F_{obt})	0.5560	0.5536	0.5634	0.5634
Avg. no. of iterations	53.3	54.7	SSU+ 46.8	SSU+ 47
¦	98.67	98.2%	99.98%	99.98%
°$_1$	85.2%	81.2	100%	100%
°$_2$	90.8%	90.4%	100%	100%
$\|\|E_d\|\|$	7.0×10^{-4}	1×10^{-3}	4.2×10^{-6}	7.9×10^{-6}

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The obtained fitness of f_2 using SSU is shown in part (a) of Fig. 8, while part (b) shows the results of using SSM, in which, the obtained fitness are constrained to be very close to the optimum solution.

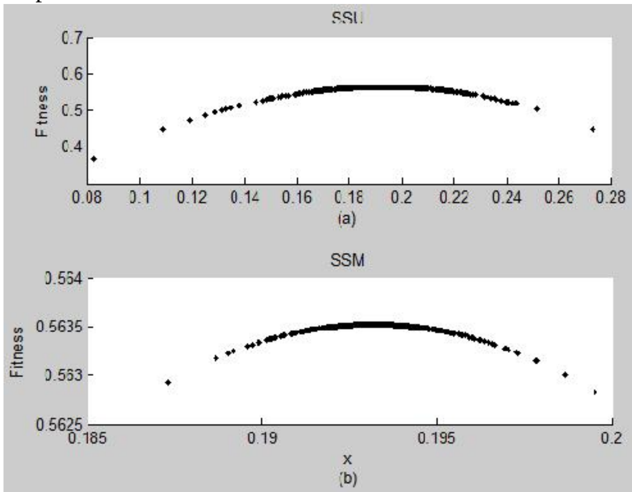

Fig. 8. Obtained fitness of f_2 (a) using SSU (b) using SSM

C. The third tested function is a polynomial with two variables described by (11) and shown in Fig. 9.

$$F_i = f_3(x,y) = x^3 - 5x^2 - 2.04y^2 + 4y \qquad (11)$$

The ranges of the solution space for this function are taken to be -3<x<3, and -3<y<3. The maximum calculated value of f_3 is 1.9608 at x=0 and y=0.9809.

The three proposed approaches are tested for the convergence toward the maximum fitness of f_3. The obtained results are summarized in table 4. In this test, although the efficiency of the SSU approach is good but its performance is not accepted in solving such a problem. The alternative is to use either the SSM approach which gives much better performance, or to use the MSU approach with not more than three search units, in which the performance is increased to be about 100% with high overall efficiency. The distribution of the x, y values for the obtained fitness using SSU and SSM are shown in Fig. 10, while Fig. 11 shows this distribution when using the MSU approach.

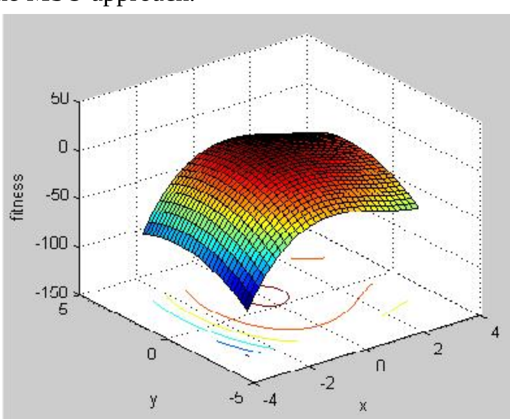

Fig. 9. Polynomial function (f_3) with two variables

TABLE 4
TEST RESULTS OF SOLVING f_3 USING SSU, SSM AND MSU

	SSU	SSM	MSU (3 units)
	Randθ	Randθ	Randθ
Max(F_{obt}) x y	1.9607 -0.0019 0.9869	1.9608 0 0.9826	1.9608 0 0.9826
Avg (F_{obt})	1.887	1.9264	1.9505
Avg. no. of iterations	33	SSU+ 11	55
¦	96.2%	98.2%	99.48%
°$_1$	30%	85%	99.8%
°$_2$	60%	98.2%	100%
$\|\|E_d\|\|$	3.7×10^{-3}	1.7×10^{-3}	6×10^{-4}

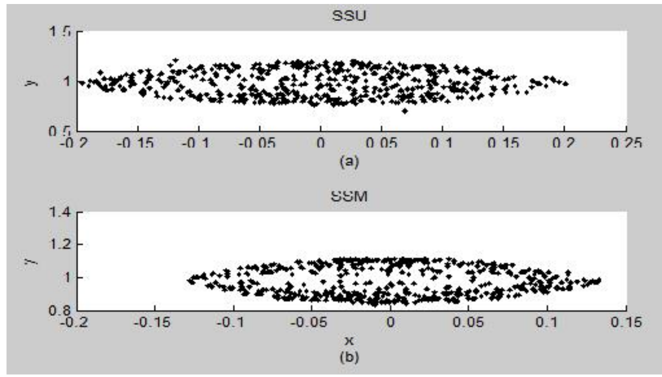

Fig. 10. Distribution of x, y values of f_3 fitness (a) using SSU, (b) using SSM

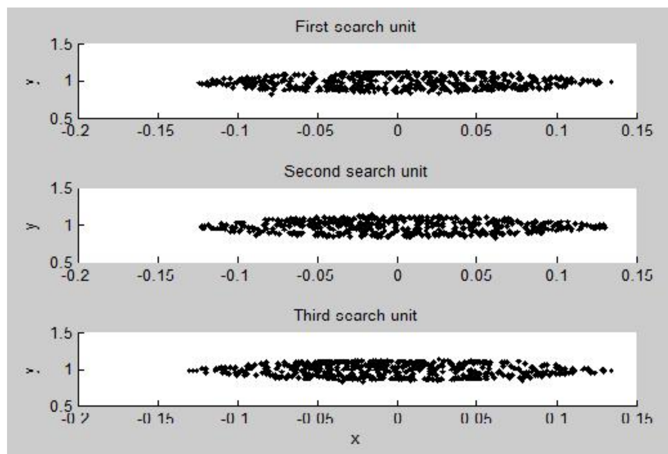

Fig. 11. Distribution of x, y values of f_3 fitness using MSU approach with three search units

D. The fourth case tests an exponential function with two variables. This function is described by (12). The ranges of the solution space are taken to be between -2 to +2 for both x and y as shown in Fig. 12.

$$F_i = f_4(x,y) = xe^{(-x^2-y^2)} \qquad (12)$$

The maximum calculated value for f_4 is 0.4289 at x=0.7072 and y=0. The obtained results of using SSU, SSM, and MSU (with three points) are contained in table 5. The three approaches converged toward the optimum point with different performances. The performance of using SSU in solving functions like f_4 is very low. Rather than the use of this

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approach its better to apply either the SSM approach or the MSU approach in which both have a performance of 100% with less Euclidean distance. The distribution of the x, y values for the obtained solutions using the above mentioned approaches are shown in Fig. 13 and Fig. 14.

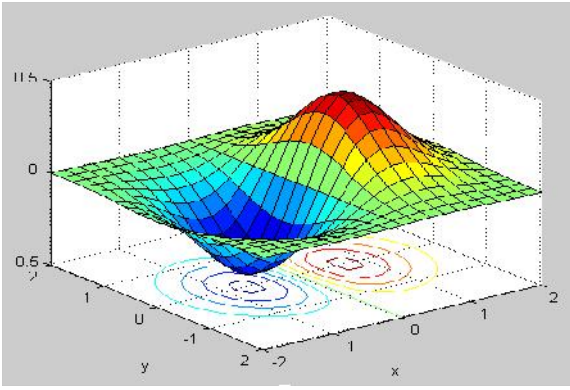

Fig. 12. Exponential function (f_4) with two variables

TABLE 5
TEST RESULTS OF f_4 USING SSU, SSM AND MSU

	SSU	SSM	MSU (3 units)
	Randθ	Randθ	Randθ
Max(F_{obt}) x y	0.4289 0.7086 -0.0071	0.4289 0.7086 -0.0071	0.4289 0.7083 -0.0006
Avg (F_{obt})	0.412	0.4283	0.4277
Avg. no. of iterations	21	SSU+ 29.2	62
¦	96 %	99.97%	99.7%
°$_1$	30%	100%	100%
°$_2$	53%	100%	100%
$\|\|E_d\|\|$	8.7×10^{-4}	5.2×10^{-6}	8.1×10^{-5}

E. The last test in this work considers a function with several optimum points and checks the ability of the proposed algorithm to converge towards these points. A trigonometric or a periodic function is a good example for such a case, in which these types of functions repeat their values in regular intervals or periods. The selected function for this test is:

$$F_i = f_5(x) = \sin(2x) - \cos(x) \qquad (13)$$

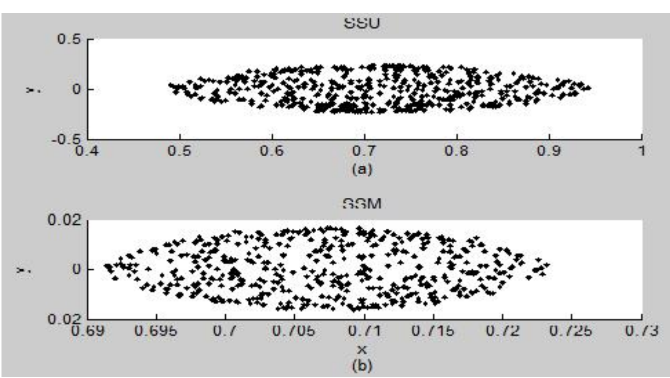

Fig. 13. Distribution of x, y values of f_4 fitness using SSU and SSM approaches

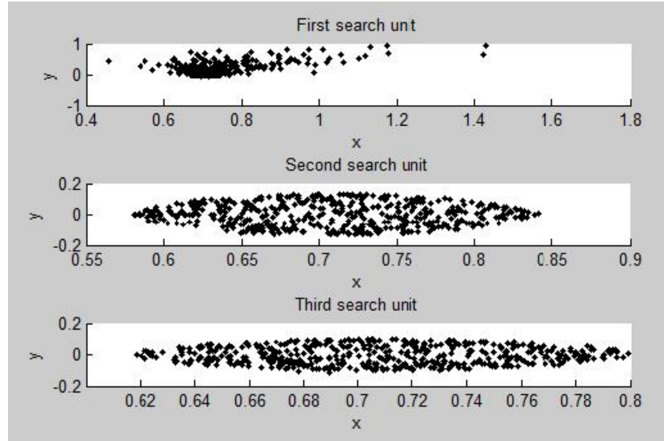

Fig. 14. Distribution of x, y values of f_4 fitness using MSU approach with three search units

The solution range is assumed to be between -2π to 2π. Within this interval, the function f_5 has two optimum values of about 1.76017 at x=-2.5067 and x=3.7765 as shown in Fig. 15.

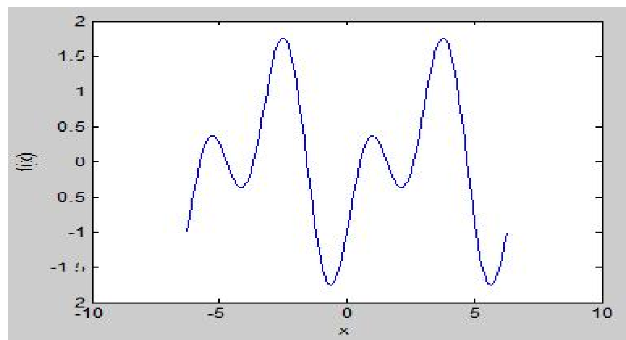

Fig. 15. Periodic function (f_5) with two global optimum values

The tested approach is the MSU with two sonar units. As mentioned before, in this approach, the search units are working in parallel in the same state space. The obtained results showed that, either both of the search units converged towards the same optimum point, or each unit converged toward a different optimum point, but in general, the algorithm observed the two global optimum points in high performance levels. The test results are as shown in table 6. It is found that the overall average fitness is very close to the optimum value (η = 99.68%) and a performance between 98.6% and 100% with acceptable Euclidean distance. The obtained fitness for this test is shown in Fig. 16.

TABLE 6
OBTAINED RESULTS OF f_5 USING MSU WITH TWO UNITS

Max(F_{obt}) x_1 x_2	1.76017 -2.5070 3.7765
Avg (F_{obt})	1.7544
Avg. no. of iterations	44
¦	99.68%
°$_1$	98.6%
°$_2$	100%
$\|\|E_d\|\|$	5.5×10^{-5}

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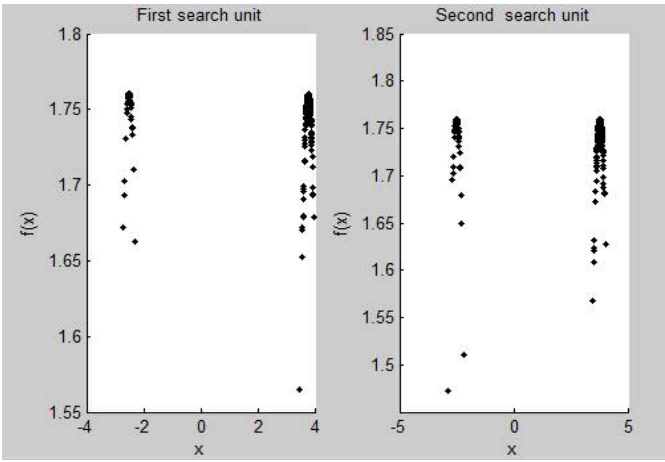

Fig. 16. Obtained fitness of f_5 using MSU with two search units

In order to evaluate the proposed algorithm, a comparison with genetic algorithm has been made, in which, the obtained fitness and the execution time for both of the algorithms are tested using the above mentioned five functions. The used platform for the two algorithms is "MATLAB® R2010b 32-bit (win32)". The results of the comparison are as declared in table 7.

In this comparison, the obtained fitnesses for the first four testbed functions are approximately the same in both of the algorithms. In function f_5, shown in Fig. 15, it is clear that there are two global and two local optimum points within the considered range space. The comparison showed that the obtained result of solving f5 using the MSS (with 2 sonar units) is much better than the result obtained by using GA. In which, the MMS algorithm observed the two global points as its best fitness, while the obtained fitness using GA algorithm is one of the local optimum.

TABLE 7
COMPARISON BETWEEN THE PROPOSED ALGORITHM AND GA ALGORITHM

Function	Algorithm	F_{obt}	x	y	Execution time (msec)
f1	SSU	15.4564	-1.40640	--	1.7
	GA	15.4562	-1.40180	--	116
f2	SSM	0.56350	0.19320	--	3.2
	GA	0.56350	0.19320	--	127
f3	SSM	1.96080	0.00000	0.98190	3
	GA	1.96080	0.00000	0.98037	119
f4	SSM	0.42890	0.70860	-0.0071	2.7
	GA	0.42890	0.70700	0.00020	123
f5	SSM	1.76017 1.76017	-2.50674 3.77650	--	2.6
	MSU with 2 units	1.76017 1.76017	-2.50674 3.77650	--	3.5
	GA	0.36900	1.00300	--	112

The other parameter that takes place in this comparison is the execution time required to solve each function. This comparison based on the following considerations:

- In the proposed algorithm, a single epoch with number of iterations = 100 is considered in solving each function.
- In GA algorithm, the default setting of the MATLAB built in function "ga" is considered, in which the maximum allowed number of generations before the algorithm halts is = 100.

As it is seen from table 7, the calculated execution times using the proposed algorithm are much less than those of the GA algorithm.

V. CONCLUSION

Intelligent algorithms are, in many cases, practical alternative techniques for solving a variety of challenging engineering problems. These techniques are, in general, attempts to mimic some of the processes taking place in natural evolution. This paper introduces a new intelligent algorithm with three search approaches depending mainly on the principles of how bat sonar can detect and capture its target. The first approach uses a single sonar unit in its search process. While the second one uses multisearch units working in parallel. This approach has been developed to reduce the execution times that are associated with the use of the first approach for finding near-optimal solutions in large search spaces and to find better solutions in larger problems. The third approach uses a single search unit with a momentum term added to the beam length. The three approaches are tested on different types of functions, such as; polynomial, exponential, and trigonometric or periodic functions. The search results show that the proposed algorithm approximately recognized all the optimum values with a reasonable efficiency and "acceptable to high" performance depending on the complexity of the problem and the number of optimum points that exist in the problem.

Although the initial values of the main parameters are selected randomly, some complex problems may need a heuristic signal to decrease the execution time and to find the optimum solution with high performance. This signal can mainly be used for the selection of the initial value of the beam length.

A comparison between the proposed algorithm of this paper and GA algorithm showed that the proposed algorithm is much better in solving problems having a local optimum. On the other hand, the required execution times for the proposed algorithm are much less than that of the GA algorithm for all the tested functions.

From the optimization point of view, the main advantage of the approaches introduced in this paper is that they do not have much mathematical requirements. All they need is an evaluation of the objective function. As a result, they can be easily applied to solving a wide class of scientific and engineering optimization problems.

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PSO-Based Optimal Fuzzy Controller Design for Wastewater Treatment Process

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Abstract—**Fuzzy logic control (FLC) is a useful modeling tool that can handle the uncertainties and nonlinearities of modern control systems. However the main drawbacks of FLC methodologies is challenging for selecting the optimum tuning parameters. The set of parameters that can be altered to modify the controller performance are fuzzy rules and the parameters of membership functions for each input variable. In all cases, the correct choice of membership functions of the fuzzy sets plays an essential role in the performance of FLC. This paper proposes a method for finding the optimum membership function parameters of a fuzzy system using particle swarm optimization (PSO). As the set of nonlinear differential equations of an aerobic unit for wastewater treatment is a multivariable nonlinear problem, the combination of PSO and FLC named PSO-FLC controller is proposed for further improvements of the system response in both the transient and steady state response. To establish its efficiency, the proposed technique was employed to enhance the triangle membership functions of the fuzzy model of a nonlinear sludge activated system; the results show that the optimized membership functions (MFs) offered better performance than a fuzzy model with heuristically described MFs**

Keywords-component; PSO; FLC controller; Wastewater treatment process;

I. INTRODUCTION

Several research trends concentrated on providing simple and easy control algorithms that faces the problem of increasing complexity of the controlled systems [1]. As, the systems involved in practice are in general complex and time variant, with delays and nonlinearities and often with poorly defined dynamics, nonlinear controllers are often developed. The main difficulty in designing nonlinear controllers is the lack of a general structure [2]. In addition, most linear and nonlinear control solutions developed during the last three decades have been based on precise mathematical models of the systems. Most of those systems are difficult to be described by conventional mathematical relations; hence, these model-based design approaches may not provide satisfactory solutions [3]. This motivates the interest in using FLC which is based on fuzzy logic theory [4,5] and employ a mode of approximate reasoning that resembles the decision making process of humans. The behavior of FLC is easily understood by a human expert, as knowledge is expressed by means of intuitive, linguistic rules. In contrast with traditional linear and nonlinear control theory, a FLC is not based on a mathematical model and is widely used to solve problems under uncertain and vague environments with high nonlinearities [6, 7]. Since their advent, FLCs have been implemented successfully in a variety of applications [8-11]. Most FLCs are designed based on the experience or knowledge of experts. However, it is often the case that no expert is available. In this case, the major task is to determine fuzzy rule base and membership function of input and output variables which are usually found by using the trial and-error method [12]. An optimal design of control rules and membership functions is usually desired as it affect on the performance of fuzzy logic based controller. Evolutionary algorithms are getting popular because of their ability to find global minima in both continuous and non-continuous domain. Most of evolutionary algorithms regarding tuning the membership function parameters of FLC have been studied extensively in the literature. Many random search methods, such as genetic algorithm [13-15], evolutionary computational techniques [16] and simulated annealing [17] have recently received much interest for achieving high efficiency and searching global optimal solution in problem space.

PSO has been a hotspot of research and promising technique for real world optimization problems [18]. Due to the simple concept, easy implementation and quick convergence, nowadays PSO has gained much attention and wide applications in different fields. PSO algorithm is especially useful for parameter optimization in continuous, multi-dimensional search spaces. PSO technique is a stochastic search through an n-dimensional problem space aiming the minimization or maximization of the objective function of the problem. Pulasinghe et al. [19] developed fuzzy–neural networks (FNNs) for navigation of a mobile robot and for motion control of a redundant manipulator. They employed PSO to train the FNNs that can accurately output the crisp control signals for the robot systems. Mukherjee et al. [20] studied regarding the determination of optimal PID gains for automatic voltage regulator (AVR). Wong et al. [21] proposed a motion control structure with a distance fuzzy controller and an angle fuzzy controller for the two-wheeled mobile robot. They used PSO algorithm to automatically determine appropriate membership functions of these two fuzzy systems. The work in [22] proposed a method for finding the optimum membership functions of a fuzzy system using PSO algorithm to design a controller for a continuous stirred tank reactor

(CSTR) with the aim of achieving the accurate and acceptable desired results. Also, in [23] an intelligent speed controller for DC motor is designed by combination of the fuzzy logic and PSO algorithm. In [24], a novel adaptive fuzzy robust controller with a state observer approach based on the hybrid particle swarm optimization-simulated annealing (PSO-SA) technique for a class of multi-input multi-output (MIMO) nonlinear systems with disturbances is proposed. PSO-SA is used to adjust the fuzzy membership functions. The proposed algorithm consists of the adaptive fuzzy robust method, the individual enhancement scheme and PSO-SA structure which generate new optimal parameters for the control scheme.

In this paper, the hybrid of PSO and FLC named PSO-FLC algorithm is proposed for the optimum design of membership function of FLC controller to the biological aerobic wastewater treatment process for further improvements of system response in both the transient and steady state response. The performance of the system is compared with the standard FLC controller. Experimental studies on tuning the parameters of membership function of FLC to the wastewater treatment process show that the system has higher fitness and better time response than the standard FLC.

The rest of paper is organized as follows: section 2 presents the biological wastewater treatment process and its dynamic model. An overview of the standard PSO is presented in section 3. A brief description of the FLC and the proposed PSO-FLC controller to wastewater treatment process in addition to the error function used for evaluating the performance of the proposed algorithm in optimizing the parameters of membership function of FLC are described in details in section 4. Experimental results and discussions are presented in section 5. Finally, section 6 concludes the whole work.

II. The Biological Wastewater Treatment with an Activated-Sludge Process

The most common method for wastewater treatment is the biological processes in which the influent wastewater goes through several stages in which different compound are removed out of the wastewater. An important part of the municipal wastewater treatment is the removal of organic matter which is dissolved in wastewater. The removal of organic matter by a biological process, such as the suspended growth treatment process is an aerobic process which takes place in the aeration tank, in where the wastewater is aerated with oxygen using an activated sludge. The activated sludge process is probably the most versatile and effective of all waste treatment processes [25] and is usually constituted by a bioreactor (the aeration reactor) and a settler (secondary clarifier) as shown in figure 1.

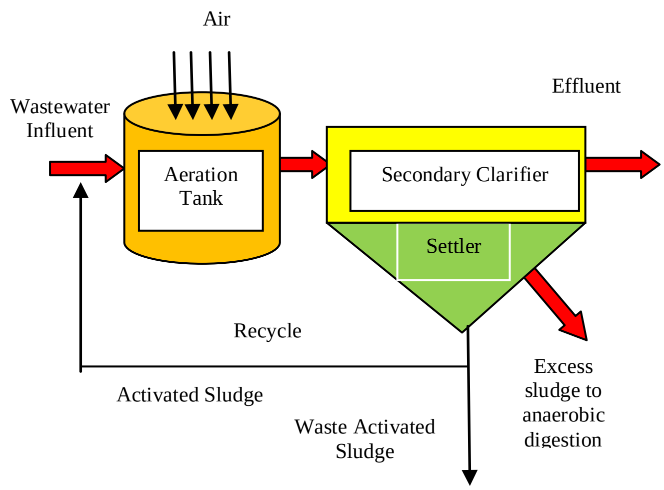

Figure 1. Schematic diagram of Aerobic treatment unit

The oxygen is injected in the aerator by compressed air and the suspended micro-organisms are separated completely in the settler. In this process, microorganisms in the aeration tank convert dissolved organic material in wastewater to into their own biomass (microbial biomass) and carbon dioxide (CO_2). Both of organic nitrogen and organic phosphorus is converted to ammonium ion or nitrate and orthophosphate. The microbial cell matter formed as part of the waste degradation processes is normally kept in the aeration tank until the microorganisms are past the log phase of growth, at which point the cells flocculate relatively well to form settle-able solids (flocks). These solids collect in the bottom part of a settler and fraction of them is discarded. Part of the solids, the return sludge, is recycled to the head of the aeration tank and comes into contact with fresh sewage. The combination of a high concentration of "hungry" cells in the return sludge and a rich food source in the influent sewage provides optimum conditions for the rapid degradation of organic matter. The activated sludge process removes organic carbon from water by conversion to CO_2 and by incorporation into biomass [26]. The disposal of waste sludge from an activated sludge plant can be a problem, primarily because it is only about 1% solids and contains many undesirable components. Normally, partial water removal is accomplished by drying on sand filters, vacuum filtration, or centrifugation.

A. Dynamic Model of Activated Sludge process

The mass balance on the bioreactor and the settler gives the following set of nonlinear differential equations:

$$X^{\bullet}(t) = \mu(t)X(t) - D(t)(1+r)X(t) + rD(t)X_r(t) \qquad (1)$$

$$S^{\bullet}(t) = -\mu(t)X(t)/Y - D(t)(1+r)S(t) + D(t)S_{in} \qquad (2)$$

$$\begin{aligned} C^{\bullet}(t) = {} & -K_o\mu(t)X(t)/Y - D(t)(1+r)C(t) \\ & + K_{La}(t)(C_S - C(t)) + D(t)C_{in} \end{aligned} \qquad (3)$$

$$X_r^{\bullet}(t) = D(t)(1+r)X(t) - D(t)(\beta+r)X_r(t) \qquad (4)$$

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Where:

$X(t)$: the state variable representing the biomass,

$S(t)$: the state variable representing the substrate,

$X_r(t)$: the state variable representing the recycled biomass,

$C(t)$: the state variable representing the dissolved oxygen,

$D(t)$: the dilution rate ($D(t) = q(t)/V$) where $q(t)$ and V are the influent flow rate and the inner aerator volume respectively,

S_{in}: substrate concentrations in the feed stream

C_{in} : dissolved oxygen concentrations in the feed stream

$K_{La}(t)$: Oxygen transfer rate coefficient

r and β are the ratio of recycled flow to influent flow and the ratio of waste flow to influent flow respectively.

The kinetics of the cell mass production are defined in terms of the specific growth rate μ and the yield of cell mass Y; the term K_0 is a constant, C_S is the maximum dissolved oxygen concentration. In this study, it is assumed that the constants (C_S, K_0, Y) and the parameters (r, β) are known. The specific growth rate μ(t) is well defined and modeled by Olsson model, depending on substrate and dissolved oxygen concentrations as follows:

$$\mu(t) = \mu_{\max} S(t)/(K_S + S(t))(K_c + C(t)) \tag{5}$$

Where: μ_{max} is the maximum specific growth rate, K_s is the affinity constant and K_c is the saturation constant [26, 27].

B. Controller Design for Activated Sludge

In this paper, the development of the best controller for activated sludge wastewater treatment process based mathematical insight is considered. Two main targets in treatment wastewater process must be achieved; the reduction of the organic matter concentration (pollutant substrate S(t)) and the dissolved oxygen concentration (air flow rate W(t)) must be kept above a critical level to maintain the microorganism activity. This quantity appears in equation (3) through the oxygen transfer rate coefficient $K_{La}(t)$ as follows:

$$K_{La}(t) = W(t)\alpha \qquad where\,(\alpha : constant \succ 0) \tag{6}$$

The objective of the control here is to regulate the substrate S(t) and the dissolved oxygen concentrations C(t) at desired set points S^* *and* C^* respectively by acting on the dilution rate D(t) and on the aeration rate W(t). The typical values of kinetic parameters and initial conditions are given in table 1 and table 2, [26].

TABLE I. KINETIC PARAMETERS

Y = 0.65	$\mu_{\max} = 0.15\ h^{-1}$
r = 0.6	$K_S = 100\ mg.l^{-1}$
$\beta = 0.2$	$K_0 = 0.5$
$\alpha = 0.018$	$C_S = 10\ mg.l^{-1}$
$K_c = 2\ mg.l^{-1}$	

TABLE II. INTIAL CONDITIONS

$X(0) = 215\ mg.l^{-1}$	$C(0) = 6\ mg.l^{-1}$
$S(0) = 55\ mg.l^{-1}$	$S_{in} = 200\ mg.l^{-1}$
$Xr(0) = 400\ mg.l^{-1}$	$C_{in} = 0.5\ mg.l^{-1}$

To regulate the substrate and the dissolved oxygen concentrations at the set points S^* *and* C^* respectively, two controllers are used. The first controller will act on the air flow rate W(t) to maintain C(t) at the required set point while the second controller will act on the dilution rate D(t) to maintain substrate concentration S(t) at the required set point. In our paper, the output of each controller depends on both the error (e) which is defined as the difference between the set point and the controlled variable and error derivative (derror) for efficient control. The main objective of any designed controller is to maintain the magnitude of the error as small as possible to improve the steady state response. On the other hand the controller should improve the transient response by reducing the settling time and the rise time, and eliminating or reducing the overshoots without causing sluggish response. In the following sections, an overview of PSO and the complete activated sludge control system using FLC is introduced, as well as PSO for optimum design of membership function of FLC are investigated.

III. AN OVERVIEW OF PSO

PSO is mainly inspired by social behavior patterns of organisms that live and interact within large groups. In particular, PSO incorporates swarming behaviors observed in flocks of birds, schools of fish, or swarms of bees. PSO refers to a relatively new family of algorithms that may be used to find optimal or near to optimal solutions to numerical and qualitative problems. PSO was firstly proposed by Eberhart and Kennedy [2], and it is initialized with a group of random particles (solutions) and then searches for optima by updating generations. Each particle in the swarm is updated by two "best" values. The first one is the best solution (fitness) it has achieved so far and it is called *Pbest*. The other best value is the global best in the whole swarm and called *gbest*. After finding the two best values, the particle updates its velocity and positions using the following equation (7) and (8).

$$v(k+1) = w * v(k) + c1 * rand() * (pbest(k) - x(k)) + c2 * rand() * (gbest(k) - x(k)) \tag{7}$$

$$x(k+1) = x(k) + v(k+1) \tag{8}$$

Where: v(k+1), v(k) are the particle velocity in iteration number k+1, k respectively, x(k+1), x(k) are the particle position in iteration number k+1, k respectively. Rand is a random number between (0, 1). c1 is called the self confidence and usually it takes values in the range (1.5 to 2.0), and c2 is called the swarm confidence and usually takes the value in the range (2.0 to 2.5). w is the inertia weight which is used to achieve a balance in the exploration and exploitation of the search space and plays very important role in PSO convergence behavior. The inertia weight is dynamically reduced from 1.0 to near 0 in each generation based on the following equation:

$$w_i = w_{\max} - \frac{w_{\max} - w_{\min}}{iter_{\max}} . iter \qquad (9)$$

Where: $iter_{\max}$ is the maximum number of iterations, and $iter$ is the current number of iteration. w_{max}, and w_{min} are the maximum and minimum values of inertia weight. The Position of each particle is updated using its velocity vector as shown in Equation (8). In this paper PSO algorithm is proposed for the optimum design of the parameters of membership functions of FLC which is described in the following section.

IV. FLC CONTROLLER

FLC is popular technique that has seen increasing interest in the past decades since it has a linguistic based structure and its performance are quite robust for non-linear systems. FLC has three main components such as fuzzification, fuzzy inference engine (decision logic), and defuzzification stages. The block diagram of FLC process is shown in Fig. 2.

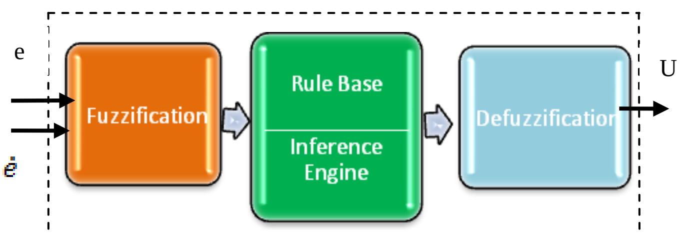

Figure 2. Fuzzy Logic process

The first block in the figure is the fuzzification which converts each element of input data to degrees of membership by a lookup in one or several membership functions. The rule base and inference base have the capability of simulating human decision-making. Both of rule base and inference engine based on fuzzy concepts and the capability of inferring fuzzy control actions employing fuzzy implication and the rules of inference in fuzzy logic. Rules are in the form of if-then rules (antecedent and consequent). The membership functions of the fuzzy sets and the fuzzy control rules have a big effect on control performance [29-31]. The third operation is called as defuzzification. The resulting fuzzy set is defuzzified into a crisp control signal. There are five defuzzification methods: centroid, bisector, middle of maximum, largest of maximum, and smallest of maximum [31].

In the presented work, two fuzzy logic controllers are used; each one of them will determine its output according to error and derivative of error (derror). The block diagram of the complete activated sludge control system using FLC is shown in Figure (3)

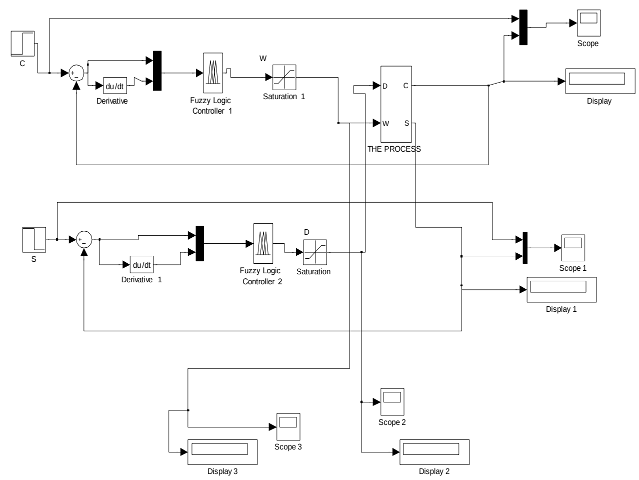

Figure 3. Simulink model of FLC for Activated sludge system

The two controllers mentioned above are: controller1 to control the dissolved oxygen concentration and controller2 to control mainly the substrate concentration. In the following section, each controller will be introduced with more details.

A. Controller 1

This controller is described by the membership functions of error and error derivative of the first input (input1) and its corresponding output air flow rate W(t). The values of the error and derror are scaled to the interval of [-3 3] and [-15 15] for the first input (input1). The FLC inputs are composed of the five linguistic terms which are: Negative Big (--), Negative Medium (-), Zero (0), Positive Medium (+) and Positive Big (++) as described in Figure 4. Both the outputs of the two FLC W(t) and D(t)) are partitioned into five fuzzy sets which are (VS, S, M, B, and VB).

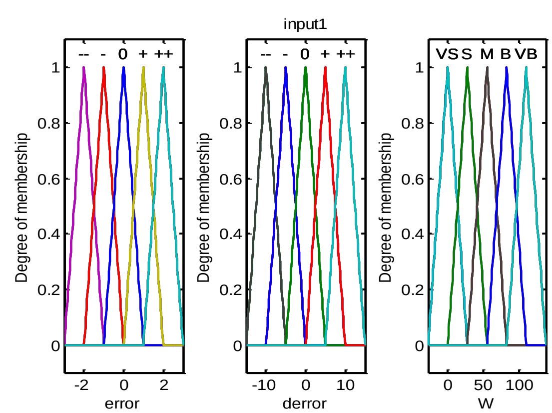

Figure 4. The normalized Membership function of fuzzy sets of input1 and its output for first controller before tuning.

The rules which manage the relation between the two inputs and the corresponding output of the first controller are given in table 3.

TABLE III. RULES OF THE FIRST CONTROLLER

1. If (error is --) and (derror is --) then (W is VS)	**(1)**
2. If (error is --) and (derror is -) then (W is VS)	**(1)**
3. If (error is --) and (derror is 0) then (W is VS)	**(1)**
4. If (error is --) and (derror is +) then (W is S)	**(1)**
5. If (error is --) and (derror is ++) then (W is M)	**(1)**
6. If (error is -) and (derror is --) then (W is VS)	**(1)**
7. If (error is -) and (derror is -) then (W is VS)	**(1)**
8. If (error is -) and (derror is 0) then (W is VS)	**(1)**
9. If (error is -) and (derror is +) then (W is M)	**(1)**
10. If (error is -) and (derror is ++) then (W is B)	**(1)**
11. If (error is 0) and (derror is --) then (W is VS)	**(1)**
12. If (error is 0) and (derror is -) then (W is S)	**(1)**
13. If (error is 0) and (derror is 0) then (W is VB)	**(1)**
14. If (error is 0) and (derror is +) then (W is B)	**(1)**
15. If (error is 0) and (derror is ++) then (W is VB)	**(1)**
16. If (error is +) and (derror is --) then (W is S)	**(1)**
17. If (error is +) and (derror is -) then (W is M)	**(1)**
18. If (error is +) and (derror is 0) then (W is VB)	**(1)**
19. If (error is +) and (derror is +) then (W is VB)	**(1)**
20. If (error is +) and (derror is ++) then (W is VB)	**(1)**
21. If (error is ++) and (derror is --) then (W is M)	**(1)**
22. If (error is ++) and (derror is -) then (W is B)	**(1)**
23. If (error is ++) and (derror is 0) then (W is VB)	**(1)**
24. If (error is ++) and (derror is +) then (W is VB)	**(1)**
25. If (error is ++) and (derror is ++) then (W is VB)	**(1)**

B. Controller 2

This controller is described by the membership functions of error and error derivative of the second input (input2) and its corresponding output the dilution rate (D(t)) as shown in Figure 5. The values of the error and derror are scaled to the interval of [-7.5 7.5] and [-15 15] for the second input (input2). The rules which manage the relation between the controller's inputs and output are given in table 4.

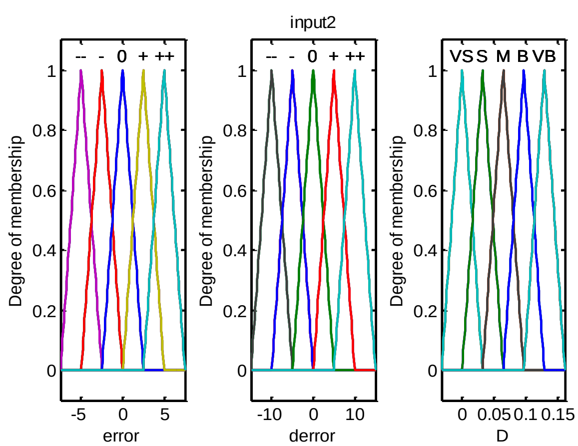

Figure 5. The normalized Membership function of fuzzy sets of input2 and its output for second controller before tuning.

TABLE IV. THE RULES OF THE SECOND CONTROLLER

1. If (error is --) and (derror is --) then (D is B)	**(0.1)**
2. If (error is --) and (derror is -) then (D is VS)	**(0.1)**
3. If (error is --) and (derror is 0) then (D is VS)	**(0.9)**
4. If (error is --) and (derror is +) then (D is S)	**(0.9)**
5. If (error is --) and (derror is ++) then (D is M)	**(0.1)**
6. If (error is -) and (derror is --) then (D is VS)	**(0.1)**
7. If (error is -) and (derror is -) then (D is VS)	**(0.1)**
8. If (error is -) and (derror is 0) then (D is S)	**(0.9)**
9. If (error is -) and (derror is +) then (D is M)	**(0.1)**
10. If (error is -) and (derror is ++) then (D is B)	**(0.1)**
11. If (error is 0) and (derror is --) then (D is VS)	**(0.1)**
12. If (error is 0) and (derror is -) then (D is S)	**(0.1)**
13. If (error is 0) and (derror is 0) then (D is M)	**(0.9)**
14. If (error is 0) and (derror is +) then (D is B)	**(0.1)**
15. If (error is 0) and (derror is ++) then (D is VB)	**(0.1)**
16. If (error is +) and (derror is --) then (D is S)	**(0.1)**
17. If (error is +) and (derror is -) then (D is M)	**(0.1)**
18. If (error is +) and (derror is 0) then (D is B)	**(0.9)**
19. If (error is +) and (derror is +) then (D is VB)	**(0.1)**
20. If (error is +) and (derror is ++) then (D is VB)	**(0.1)**
21. If (error is ++) and (derror is --) then (D is M)	**(0.1)**
22. If (error is ++) and (derror is -) then (D is B)	**(0.1)**
23. If (error is ++) and (derror is 0) then (D is VB)	**(0.9)**
24. If (error is ++) and (derror is +) then (D is VB)	**(0.1)**
25. If (error is ++) and (derror is ++) then (D is VB)	**(0.1)**

In our paper, the correct choice of membership functions of the fuzzy sets plays an essential role in the performance of our FLC which is developed by using PSO for tuning its membership function as described in the following section.

C. The proposed algorithm of PSO-FLC

As described before, each FLC has three variables; two inputs (error and derror) and one output with 5 fuzzy sets for each variable which corresponding to 15 MFs and 25 rules for each controller. Each fuzzy set is triangle shape and is represented by three parameters which are x-coordinates of the three vertices of the triangle. Consequently, there are 45 parameters for each controller, means 90 parameters in this study for the two controllers to be optimized. PSO searches all of the antecedent and consequent parameters (inputs and outputs controller) in 90 dimensional spaces. The order of a particle is shown as the following:

$$\begin{aligned} P_i = \; & a_{11}b_{11}c_{11}\ldots\ldots a_{15}b_{15}c_{15}, a_{21}b_{21}c_{21}\ldots\ldots a_{25}b_{25}c_{25}, a_{31}b_{31}c_{31}\ldots\ldots a_{35}b_{35}c_{35}, \\ & a_{41}b_{41}c_{41}\ldots\ldots a_{45}b_{45}c_{45}, a_{51}b_{51}c_{51}\ldots\ldots a_{55}b_{55}c_{55}, a_{61}b_{61}c_{61}\ldots\ldots a_{65}b_{65}c_{65} \end{aligned} \quad (10)$$

Where: b, a, and c represent the center and the left and right deviation from the center of triangle membership (x-coordinate of the three vertices) as shown in figure 6. In the above equation, the first line and the second line constitute the parameters of the first controller and the second controller, respectively, which are 2 inputs and one output with 15 MFs for each controller. The initial values of the first particle are generated with the normal values by equally dividing the range of each input and output on 5 fuzzy sets values, while the remaining particles are randomly generated in the first generation by associating an interval of performance for each parameter in the particle. Each interval of performance will be the interval of adjustment for each correspondent variable.

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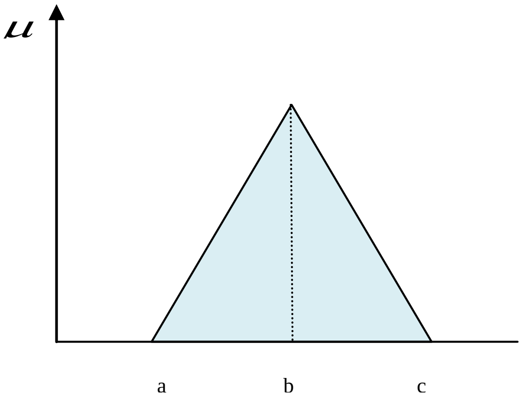

Figure 6. The triangle membership function

For the three variables a, b and c of each fuzzy set, the intervals of performance are: $a \in (a^l, a^r),\ b \in (b^l, b^r)$ and $c \in (c^l, c^r)$

These variables are described as follows:

$$a \in [a^l, a^r] = \left[a - \frac{b-a}{2}, a + \frac{b-a}{2}\right]$$

$$b \in [b^l, b^r] = \left[b - \frac{b-a}{2}, b + \frac{c-b}{2}\right]$$

$$c \in [c^l, c^r] = \left[c - \frac{c-b}{2}, c + \frac{c-b}{2}\right]$$

The most crucial step in applying PSO is to choose the best membership parameters by searching the best value of cost function which is used to evaluate the fitness of each particle. During tuning process with PSO, two different cost functions are used such as Mean of Squared Error (MSE) and integral of Absolute Magnitude of the Error (IAE) to investigate the performance of the proposed technique. The fitness of each particle in the swarm is evaluated depending on the two following objective functions:

- Mean of the Square of the Error (MSE)

$$I_{MSE} = \frac{1}{n}\sum_{t=0}^{n}(e_1(t))^2 + (e_2(t))^2 \qquad (11)$$

-Integral of Absolute Magnitude of the Error (IAE)

$$I_{IAE} = \int_{t=0}^{n}|e_1(t)|dt + |e_2(t)|dt \qquad (12)$$

Where: e_1 and e_2 are the errors between system input1 and input2 and their corresponding outputs W(t) and D(t) calculated over a time interval t respectively, and n is the number of samples. The effectiveness of the proposed PSO-FLC algorithm in comparison with the FLC without tuning is tested using the above two performance indices. The plant system with the tuned FLC parameters using PSO is shown in figure 7. Membership functions Tuning by using PSO and the two objective functions MSE and IAE are shown in the figures 8 and 9

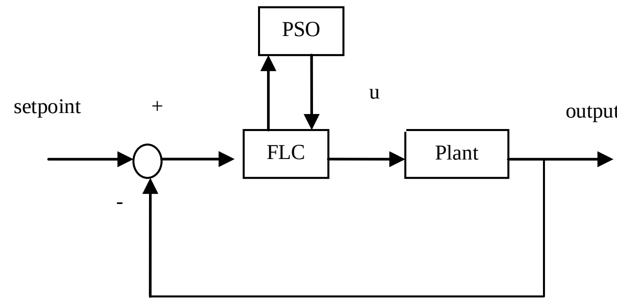

Figure 7. Tuning process of FLC parameters with PSO

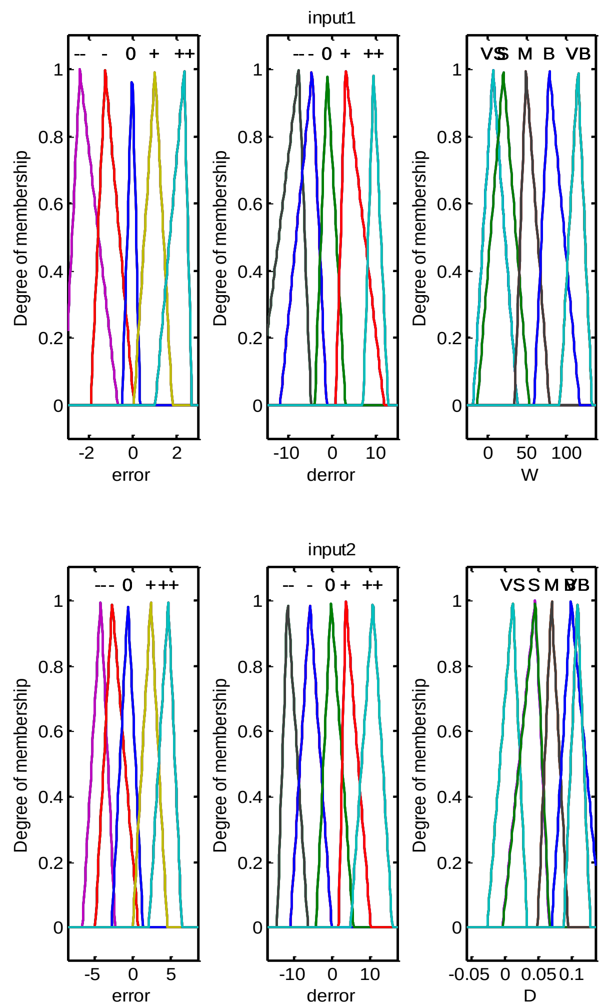

Figure 8. Tuning membership functions of the two FLC controllers using MSE

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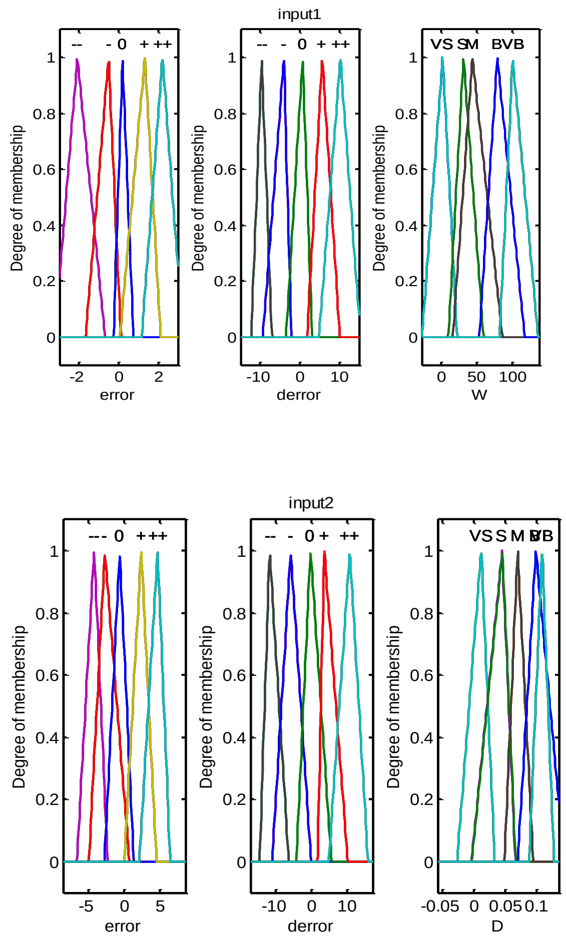

Figure 9. Tuning membership functions of the two FLC controllers using IAE

V. SIMULATION RESULTS OF PSO-FLC

To test the performance of the system for sudden change situation and to check the robustness of the controllers, two set points for each controlled variable are applied in interval 100 hour (h). The set points represent the upper and lower bound of the controlled variable as depicted in table 5.

TABLE V. THE SET POINTS FOR BOTH SUBSTRATE AND DISSOLVED OXYGEN

Time interval	Dissolved oxygen set points C*	substrate set points S*
0 < t < 50 h	5mg/l	50mg/l
50 < t < 100 h	6.5mg/l	30mg/l

The actual and the desired values for both the dissolved oxygen concentration C(t) in mg/l and the substrate concentration S(t) in mg/l versus the time in interval 100 hour are presented in the following figures. The set point for each controller will take the shape of step representing the controlled variable bounds. To verify the efficiency of the proposed algorithm, experiments have been carried out for optimal tuning of fuzzy controller to wastewater treatment process. The performance results of FLC controller tuned by PSO using IAE, and ISE performance indices are compared with the standard FLC. The cost function is calculated as an average over 10 runs for 20 generations. The resulted time response of two outputs system using the two performance indices are shown in Figures 10-13 respectively. Also, the cost functions for the two performance indices are shown in Figures 14-15. Tables 6-9 give comparison of the transient response characteristics for the two outputs C(t) and S(t) with PSO-FLC controller using MSE, and IAE performance indices and the standard FLC.

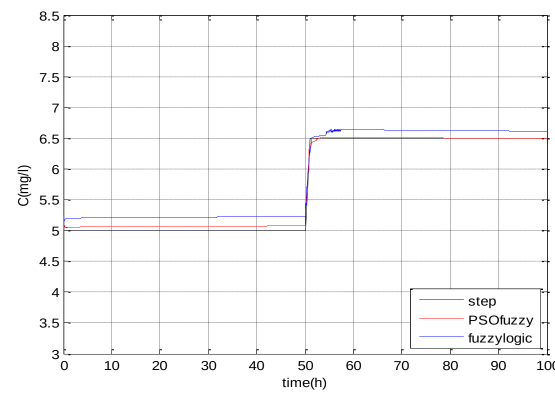

Figure 10. The output value of C(t) with PSO_FLC and standard FLC using MSE

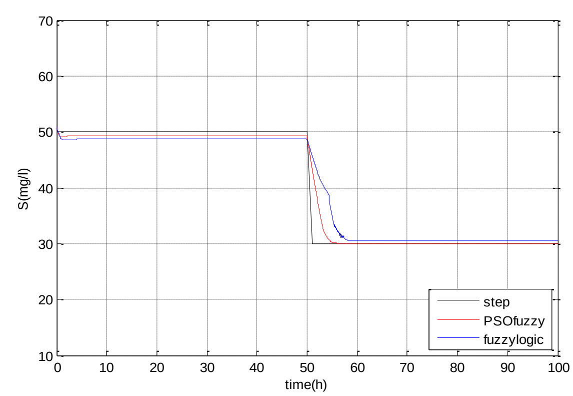

Figure 11. The output value of S(t) with PSO-FLC and standard FLC using MSE.

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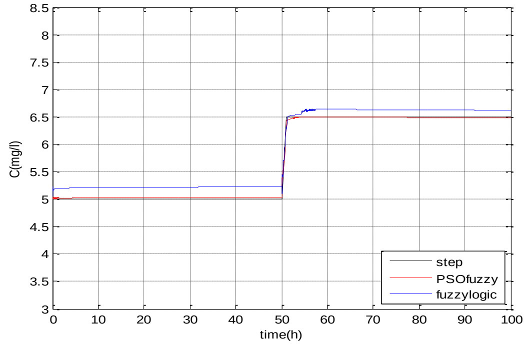

Figure 12. The output value of C(t) with PSO-FLC and standard FLC using IAE

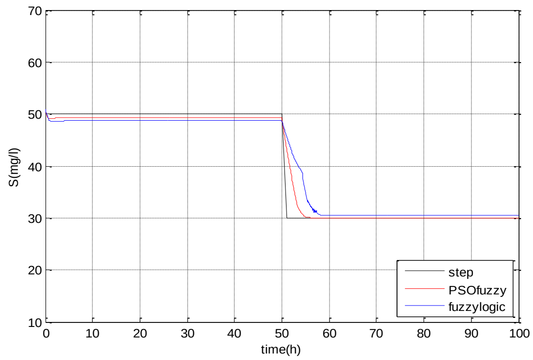

Figure 13. The output value of S(t) with PSO-FLC and standard FLC using IAE.

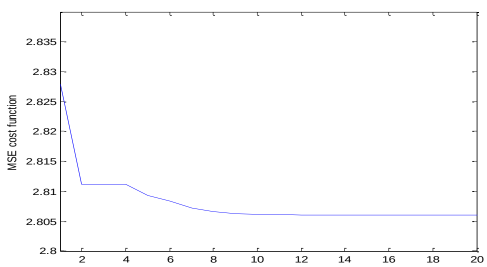

Figure 14. Cost function of PSO-FLC using MSE result

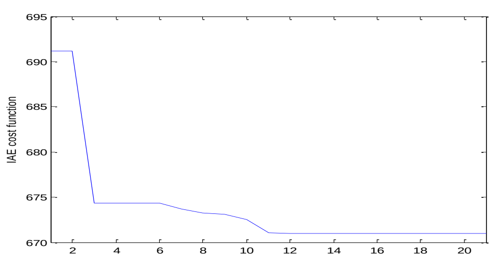

Figure 15. Cost function using of PSO-FLC using IAE

TABLE VI. TRANSIENT RESPONSE CHARACTERISTICS OF DISSOLVED OXYGEN CONCENTRATION AND COST FUNCTION OF WASTEWATER TREATMENT PROCESS USING MSE CRITERIA

MSE criterion	*FLC controller*		PSO-FLC controller	
	SP=5	*SP=6.5*	*SP=5*	*SP=6.5*
t_r(h.)	0.076	3.02	0.028	0.82
M_p	4.6%	*2.1%*	1.5%	0%
t_s(h.)	23	6.5	21	2.4
ess	*4.5%*	*1.8%%*	*1.4%*	*0%*

TABLE VII. TRANSIENT RESPONSE CHARACTERISTICS OF SUBSTRATE CONCENTRATION AND COST FUNCTION OF WASTEWATER TREATMENT PROCESS USING MSE CRITERIA

MSE criterion	*FLC controller*		PSO-FLC controller	
	SP=50	*SP=30*	*SP=50*	*SP=30*
t_r(h.)	.70	5.2	0.4	3
M_p	*2%*	1.9%	2%	0%
t_s(h.)	*13.4*	7.5	7.9	4.8
ess	*2.4%*	*2%*	*1.4%*	*0%*

TABLE VIII. TRANSIENT RESPONSE CHARACTERISTICS OF DISSOLVED OXYGEN CONCENTRATION AND COST FUNCTION OF WASTEWATER TREATMENT PROCESS USING IAE

IAE criterion	*FLC controller*		PSO-FLC controller	
	SP=5	*SP=6.5*	*SP=5*	*SP=6.5*
t_r(h.)	0.076	1.12	0.023	0.78
M_p	4.6%	*2.1%*	1%	0%
t_s(h.)	23	6.9	21	1.8
ess	*4.5%*	*1.8%%*	*0.54%*	*0%*

TABLE IX. TRANSIENT RESPONSE CHARACTERISTICS OF SUBSTRATE CONCENTRATION AND COST FUNCTION OF WASTEWATER TREATMENT PROCESS USING IAE

IAE criterion	*FLC controller*		PSO-FLC controller	
	SP=50	*SP=30*	*SP=50*	*SP=30*
t_r(h.)	.70	5.2	0.4	3.8
M_p	*2%*	1.9%	2%	0%
t_s(h.)	*13.4*	7.5	8.07	4.8
ess	*2.4%*	*2%*	*1.3%*	*0%*

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Simulation results demonstrate the superiority of PSO-FLC comparing with the standard FLC. As shown and comparing to the standard FLC, PSO-FLC has a lower overshoot also it has minimum settling time, and concerning the steady state error, PSO-FLC achieve lower error comparing with the standard FLC. The percentage improvements of PSO-FLC over FLC in terms of settling time, peak value, and the value of steady state error using MSE, and IAE metrics are depicted in tables 10-12 as follows.

TABLE X. IMPROVEMENTS IN THE SETTLING TIME OF DISSOLVED OXYGEN CONCENTRATION AND SUBSTRATE CONCENTRATION WITH PSO-FLC WITH RESPECT TO STANDARD FLC

Performance criterion	PSO-FLC *controller with respect to standard FLC C*		PSO-FLC controller *with respect to standard FLC S*	
	SP=5	*SP=6.5*	*SP=50*	*SP=30*
MSE	8.6%	63%	41%	36%
IAE	8.6%	73.9%	39.7%	36%

TABLE XI. IMPROVEMENTS IN THE PEAK VALUE OF DISSOLVED OXYGEN CONCENTRATION AND SUBSTRATE CONCENTRATION OF PSO-FLC WITH RESPECT TO STANDARD FLC

Performance criterion	PSO-FLC *controller with respect to standard FLC C*		PSO-FLC controller *with respect to standard FLC S*	
	SP=5	*SP=6.5*	*SP=50*	*SP=30*
MSE	68.8%	100%	0%	100%
IAE	78.2%	100%	0%	100%

TABLE XII. IMPROVEMENTS IN THE STEADY STATE ERROR OF DISSOLVED OXYGEN CONCENTRATION AND SUBSTRATE CONCENTRATION WITH PSO-FLC WITH RESPECT TO STANDARD FLC

Performance criterion	PSO-FLC *controller C*		PSO-FLC controller *S*	
	SP=5	*SP=6.5*	*SP=50*	*SP=30*
MSE	68.8%	100%	41.6%	100%
IAE	88%	100%	46%	100%

VI. CONCLUSION

The design of fuzzy logic controller depends on a set of parameters that can alter to modify the controller performance. Among these parameters are fuzzy rules and the parameters of membership functions for each input variable. In this paper PSO for tuning the parameters of membership functions of FLC is proposed. The proposed PSO-FLC is carried out for wastewater treatment process by minimizing input-output errors using two different error functions. Two controller have been implemented, one to control the dissolved oxygen concentration through acting on air flow rate, and another to control the substrate concentration through acting on the dilution rate. The performance of the system is compared with the standard FLC. The performance of the proposed algorithm is analyzed based on two performance indices; IAE and MSE. Experimental studies on tuning the parameters of membership functions of FLC controller for wastewater treatment process show the superiority of the PSO-FLC over the standard FLC in metric of time response characteristic and error function value. As for settling time, the time of PSO-FLC is (8.6%) and (73%) less than the time taken by classical FLC for C(t) at set-points 5 and 6.5 respectively. Also for S(t) at set-points 50 and 30, the time of PSO-FLC is (41%) and (36%) less than the time taken by classical FLC. The maximum peak value decreased by (68.8%-100%) for both C(t) and S(t), and the improvements in steady state error is reduced by (68% -100%) and (41%-100%) for both C(t) and S(t) than the other FLC technique.

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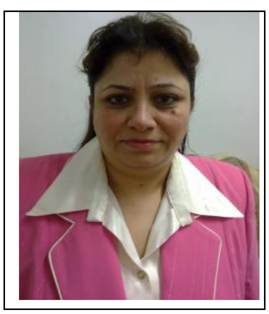

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Anomaly Based Hybrid Intrusion Detection System for Identifying Network Traffic

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Abstract— **Network intrusion detection system attempts to detect attacks at the time of occurring or after they took place. Since it is reliable and produces less alarm rate but it fails to detect unusual or new attacks. In this paper we propose a hybrid IDS by combining the anomaly based detection approaches like Packet Header Anomaly Detector (PHAD), Network Traffic Anomaly Detector (NETAD), Application Layer Anomaly Detection (ALAD) and Learning Rules for Anomaly Detection (LERAD). The hybrid IDS obtained is evaluated using the KDD Cup 99 traffic data and Tcpdump data (Real Time Data). The number of attacks detected by misuse based IDS is compared with the hybrid IDS obtained by combining anomaly and misuse based IDSs and shows that the hybrid IDS with ALAD and LERAD performs well by detecting 149 attacks out of 180 (83%) attacks after training on one week attack free traffic data**.

Keywords- **Intrusion detection; Snort, Packet Header Anomaly Detection (PHAD); Network Traffic Anomaly Detector (NETAD) ; Application Layer Anomaly Detector (ALAD); Learning Rules for Anomaly Detection (LERAD); KDD Cup99 dataset and Real time traffic data.**

I. INTRODUCTION

Internet is one of the most powerful innovations in today's world. Though it brings all kinds of people together but some may use it to breech attacks. As internet and computers are connected with each other it helps the hackers to succeed in their tasks. So the computer security over network is inevitable to prevent against attacks through firewall, cryptography, filtering and avoiding unauthorized access but all these constraints are possible only by providing preventive measures. Normally the suspicious activities can be identified only through analyzing large volumes of data that are stored in network, host, log files, etc. An Intrusion Detection System was first coined by Anderson (1980) [1] in a technical report. IDSs are used to stop attacks or recover from it with some loss and to analyze the security issues so that it can be avoided in future [2]. Computer crime security survey has been listed that ids usage in 1999 is seems to be 42% but in 2003 it has been increased to 73%. This result shows that the IDS as the immense defense weapon toward security issues. An attack is a kind of software that is made to destroy the particular task or evolving congestion over the network. According to security research community the term attack in intrusion are interchangeable. Attack can be made via internet by the hackers capturing the accessing of normal user by sniffing the password. Intrusion detection system monitors the events occurred on individual host as well as over network to determine that the security has been violated. However the number of threats seems to be increasing continuously. So IDS has become an integral part of security measures within an organization [3, 4].

IDS are of two types host and network based IDS. In HIDS [5] the data come from audit record, system logs, application program etc, by comparing with network IDS to analyze network attack or an intrusion happened to particular hosts. Whereas the encrypted packets passes over the network from the system files and then decrypted in host machine. So the data are not affected and it does not require any special kind of hardware than monitoring system installed in specific host. In network based ids commonly one Intrusion Detection System is enough for the whole LAN. It is of low cost & capable of analyzing many attacks like DoS, DDoS, etc., but HIDS fails to analyze those attacks.

Intrusion detection system has traditionally been classified into two classes namely anomaly detection and misuse/signature based detection. Misuse detection compares the upcoming network traffic to the database of known attack with the help of signatures to detect intrusions. It works efficiently in analyzing known attacks that are stored in the database. But it cannot detect new attacks that are not predefined. On the other hand, the anomaly detection approach creates a profile (normal) based on the network and hosts under inspection & raises alarms or some kind of notification to make the administrator to handle the situation. However they have being able to detect new & unusual attacks. There are two types of false alarms in determining the any deviations from normal pattern false positive and false negative. The main goal is to keep these alarms as low as possible. Data mining techniques such as association, classification, clustering and neural networks have been used in intrusion detection [6, 7]. Snort is the network based anomaly detection method. It captures the packets that are transmitted over the network by analyzing the real time traffic [8]. It depends upon the signatures that are predefined and work in terms of content

analyses basis. It saves the packet in a database as a tcpdump files. From that the data would be analyzed and alerts are made accordingly. Since it is an open source tool and mainly used for signature based detection we have chosen snort for our work. On the other hand, the anomaly detection approach creates a profile (normal) based on the network and hosts under inspection & raises alarms or some kind of notification to make the administrator to handle the situation.

In this paper the various anomaly detection approaches such as ALAD, NETAD, PHAD, and LERAD has been used to model the suspicious traffic over network rather than user behavior. Misuse based model considers only the user behavior to create the pattern but it may not be useful in all environments. In order to avoid this dependency, an anomaly based techniques has chosen for the study.

This paper is organized as follows: Section 2 provides related work dealt with a data mining approach in intrusion detection. Section 3 includes the contribution of the work. Section 4compares the misuse based and anomaly based approaches. Section 5 explains the architecture of the hybrid IDS towards computer security. Section 6 the data set used and its features in detail. Sections 6 describe the performance evaluation of various anomaly based approach. Section 7 includes experimental analysis & result. Section 8 refers to conclusion & future enhancement.

II. RELATED WORK

Anomaly Detection can be done from attack free data. Network anomaly detectors usually models low level attributes. Machine Learning and data mining techniques has proven to be beneficially applicable in intrusion detection field as they are potentially adaptable to any change according to new information acquired. Association rule is one among the widely used method to build IDS [9]. Casewell and Paxson [10, 11] used IDSs based on misuse model. Other attempts to solve intrusion detection and prevent attacks in future with reference to the information gleaned from the distributed IDS can be found in [12, 13]. Statistical based approaches assume that the network traffic accepts and act in favor of quasi stationary process. But this, situation is not applicable in realistic and leads to high false alarm rate. Due to the immense change in the behavior of global internet the attacker can easily exploit attack over network. So the intrusion detection must be done on the connection features at the network, transport layer and application layer [14, 15].

Kai Hwang et al [16] collect the anomalous traffic analyzed from internet with the help of ADS. A weighted signature scheme is developed to correlate ADS with snort thereby detecting novel attacks fastly and improves the accuracy of detection process. The signature generated by ADS improves the performance of Snort by 33%. The server or operating system compromised in UNIX system is found through call sequence method. It has been modeled using n grams and neural networks can be found in [17, 18]. Zhenwei Yu et al [19] present an automatically tuning process (ATIDS) that will automatically tune the detection process according to the report provided by the system operator in case of false prediction is achieved.

In [20] the real time & DARPA dataset has been used for the evaluation. The simulated dataset performs well while compared to mixed dataset. PHAD [21] detects 29 attacks out of 201 instances using non stationary model based on the time sequence than average frequency. NETAD system detects 132 out of 185 attacks in DARPA evaluation dataset. It uses fast filter method to locate the hostile events. Incremental LERAD provides similar accuracy as that of offline by generating fewer rules and decreasing overhead in detection process can be seen in [22]. Mahoney [23] used four anomaly detection approaches to solve the detection problem by modeling network protocol from data link layer, application layer, packet header and extracting good rules from poor set of rules. Mahoney and Chan [24] have introduced a new concept that facilitates the automatic adaptation during traffic model generation against assumption.

III. CONTRIBUTION

- High level of human interaction is needed during modeling the intrusion detection system. To solve the work load in preprocessing the snort has been used to automatically analyze the traffic.
- Based on this technique, a hybrid IDS (Snort+ALAD+LERAD) is developed according to the environment where it is deployed and validated through simulation experiments.
- The new signatures are generated from anomalies detected by snort based approach. This new approach automatically simulates NIDS to detect similar anomalous attacks in future.
- Hence this approach is useful in case of automatic detection of intrusion over network. It also detects better than other methods.

IV. METHODOLOGY

Here the misuse based and anomaly based approach has been taken for the study. Comparison is made based on its performance by analyzing the detection rate of snort of its own with the anomaly based algorithms. Here Snort requires frequent revision in order to capture new attacks from existing. Snort has predefined rules and also we can able to update any rules in future. Under anomaly based approach, we have four types of statistical methods like PHAD, NETAD, ALAD and LERAD respectively [25]. We can see it one by one,

A. SNORT

Snort is developed by Martin Roesch, a software engineer in 1990 attempts to detect attacks occurred in his computer. It is a fast; rule based and misuse detection methods written in a specific language. It is possible to integrate new functionalities within the snort during the time of compilation. It makes use of text files or tcpdump files to store the packets. Tcpdump is

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a kind of tool or program that is used to capture the various hosts in a network [26, 27].

A simple Snort rule shown in Fig. 1 is “sensitive data”. This states that, if an entry does not match with the specified constraints, a sensitive data message is stored within the snort otherwise an alert message is specified. The field can be TCP, UDP and ICMP. The protocol specified in our example is TCP followed by source and destination address.

04/23-18:04:09.543108 [**] [138:5:1] SENSITIVE-DATA Email Addresses [**] [Classification: Sensitive Data was Transmitted Across the Network] [Priority: 2] {TCP} 74.125.236.55:80 -> 192.168.1.17:4489

Figure 1. Snort Rule Structure

B. Packet Header Anomaly Detector (PHAD)

Packet Header Anomaly Detector is the first one among the four anomaly based approach that can be added to the snort for automatic identification of network traffic. It not only models protocol but also the time at which the last anomaly found in testing phase from that of training phase by monitoring both input and output traffic. It reduces the number of alarms by indicating the alarm only for the first anomaly that took place. The anomaly score is calculated by using the formula,

$$T= tn/r \qquad (1)$$

Where,
n= number of packets arrived from that the anomaly value must be searched.
r = number of values considered as normal.
t = time of the last anomaly occurred.

PHAD can model 33 attributes of packet header fields with 1 to 4 bytes. The fields that are lesser than 1 byte is taken as 1 byte and more than 4 byte is rounded to 6 byte respectively.

C. Network Traffic Anomaly Detector (NETAD)

Network Traffic Anomaly Detector is the second kind of anomaly based approach. It works as that of PHAD the only difference is that, it posses two phases. First, to filter the incoming traffic sequence is filtered to differentiate the beginning of sequence. Second is the modeling phase. The filtering phase models the traffic from 98 to 99%. Then the remaining packet enters the modeling phase. The second phase models 5 types of packets [28] such as,

- All IP packets
- All TCP packets (if protocol= TCP (6))
- TCP SYN (if TCP and flags =SYN (2))
- TCP data (if TCP and flags = ACK (16))
- TCP data for port number between 0 and 255 (if TCP and ACK and DP1 (high order bit of destination port) =0)

Anomaly score is calculated using

$$AS= tn_a (1-r/256)/r+t_i n(n_i+r/W) \qquad (2)$$

Where, n_a is the number of normal packets from where the last anomaly found. 256 is the constant coefficient value.

D. Application Layer Anomaly Detector (ALAD)

Application Layer Anomaly Detector provides conditional rules. It can be modeled by the condition that, if the probability of an event has a set of values then the other set would has some particular value. This method provides good result in the experimental study.
The general form is,

$$P= Pr (X=x\ldots..Z=z| A=a\ldots..Z=Z) \qquad (3)$$

If the consequent is X=x, Z=z then the antecedent would be A=a, B=b. It uses four rules for modeling namely,

- Pr(source IP address | destination IP address)
- Pr(source IP address | destination IP address, destination port)
- Pr (destination IP, destination port)
- Pr(TCP flags (first, next to last packet) | destination port)

E. Learning Rules for Anomaly Detector (LERAD)

Learning rules for anomaly detector monitors the TCP connections as that of ALAD and the only difference is extract the good rules form the existing set of rules. Every rule is applied to testing phase at least once. While considering the time, while the matching attribute values increases then automatically the time interval seems to be increasing. It generates rules for randomly selected sample from the training set, discard the rule which does not favors the rule n/r. Include rules for the whole training set and perform validation test by excluding the rules that performs anomaly.

V. DATA SET DESCRIPTION

Both the combination of real time traffic from LAN network and KDD cup are chosen in this study. KDD cup 99 dataset [29] has been used to analyze the network intrusion detection and it is developed by Stolfo et al based upon DARPA dataset from MIT Lincoln Laboratory as an evaluation benchmark. The dataset involves approximately 4 million connection records with 41 related features & 21 attack types. All different attacks fall into 4 major categories as dos, probe, u2r and r2l attacks labeled as attack and normal type. The attack free data from the kdd cup and LAN network are taken as training set and one week attack data from kdd cup as testing set. Attacks can be described as

A. *Dos Attack*- It is a kind of attack where the attacker makes processing time of the resources and memory busy so as to avoid legitimate user from accessing those resources.

B. *U2R Attack* - Here the attacker sniffs the password or makes some kind of attack to access the particular host in a

network as a legitimate user. They can even promote some vulnerability to gain the root access of the system.

C. *R2L Attack*- Here the attacker sends a message to the host in a network over remote system and makes some vulnerability.

D. *Probe Attack* - Attacker will scan the network to gather information and would make some violation in future.

Table. 1 Name of the attacks classified under 4 groups

Denial of Service	Back, land, neptune, pod, smurf, teardrop
Probes	Satan, ipsweep, nmap, port sweep
Remote to Local	ftp_write, , imap, guess_passwd, phf, spy, warezclient, multihop, warezmaster
User to Root	buffer_overflow, load module, Perl, root kit

VI. ARCHITECTURE OF THE HYBRID IDS

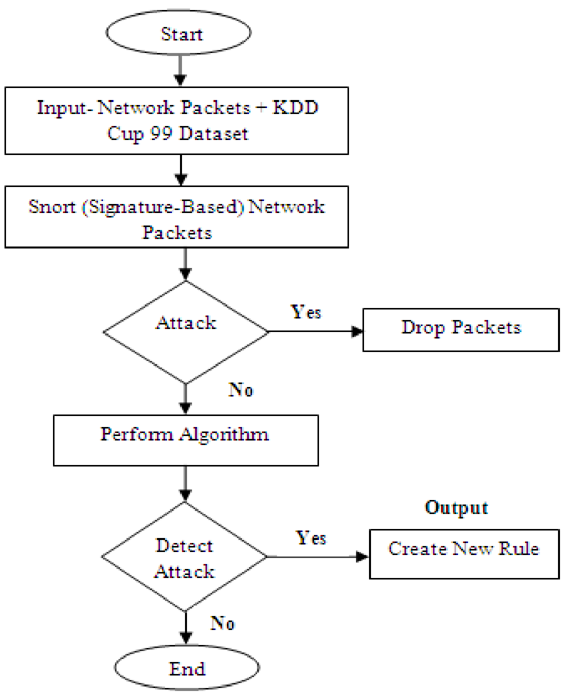

Figure 1. Block Diagram of Proposed Hybrid IDS

In figure1, snort is installed in the computer within the network. Once it is installed it automatically captures the network packets that are passed over the network. In this, we include KDD Cup 99 dataset together within the snort. Since the set of rules are predefined inside the snort. It performs the preprocessing steps as per rules. Snort gives the alert message according to the information stored in the database as tcpdump files. If any attack is found then the packet is dropped otherwise it can be taken as attack free data. Here we apply the anomaly based approach such as ALAD, PHAD, NETAD or LERAD to automate the IDS by capturing the attacks synchronizing with the network. If any suspicious traffic/attack is found, it analysis the exact cause of it and creates the signature and finally included within the rule set in snort.

VII. EXPERIMENTAL RESULTS

Hybrid IDS is developed to overcome the human interaction towards pre-processing. Most of the evaluation on intrusion detection is based on proprietary data and results are not reproducible. To solve this problem, KDD cup 99 has been used. Lack of public data availability is one of the major issues during evaluation of intrusion detection system. Totally out of 500 instances, 320 instances involved in training phase and remaining 180 instances are taken for testing phase. Analysis is done based on the scenarios given below:

A. *Based on Snort*
B. *Based on Snort + PHAD*
C. *Based on Snort +PHAD+ALAD*
D. *Based on Snort + ALAD+LERAD*

A. *Performance of Snort*

Snort is tested on real time traffic and simulated dataset (one week data including attack) and attacks detected are listed day by day. The files have been downloaded from [30] and LAN network. Attack detected on daily order is shown in the below figure2. Snort has detected 77 attacks out of 180 attacks without adding any anomaly based approaches.

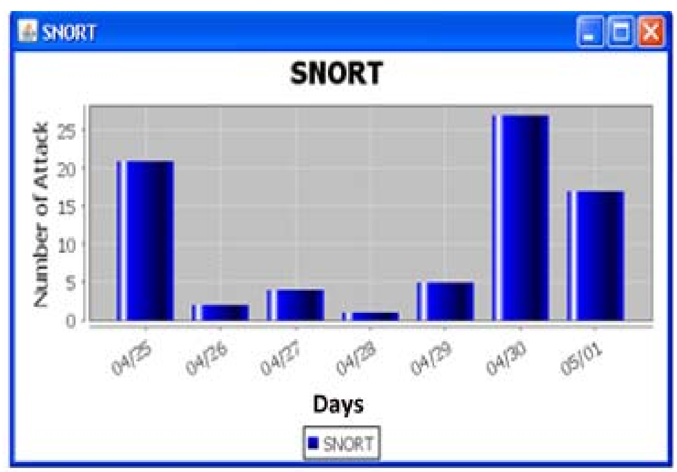

Figure 2. Attacks detected by snort on a daily basis

B. *Performance of Snort+PHAD*

Attacks detected by Snort, LERAD and NETAD on their own and results in hybrid intrusion detection system (Snort + PHAD+NETAD) are shown in figure4. It is understood that after adding PHAD with Snort it detects better than before. The number of attacks detected by Snort increases from 77 to 105 in Snort+PHAD version of IDS.

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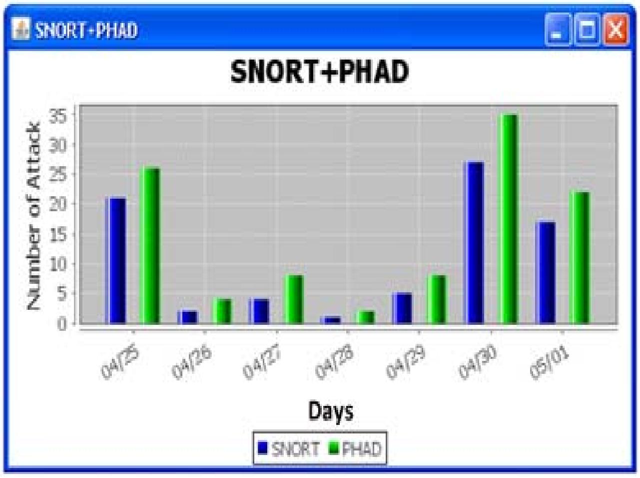

Figure 3. Attacks detected by Snort+PHAD on a daily basis

C. Performance of Snort+PHAD+ALAD

When PHAD and ALAD are added to the snort it detects more attacks than before. It is clearly shown from the graph Fig.3 that the number of attacks increases while adding PHAD and ALAD with Snort the IDS becomes powerful. The number of attacks detected by Snort+PHAD increase from 105 to124 in Snort+ PHAD+ALAD. The main reason is Snort detects the attacks based on rule definition files but PHAD and ALAD detects using packet header and network protocol.

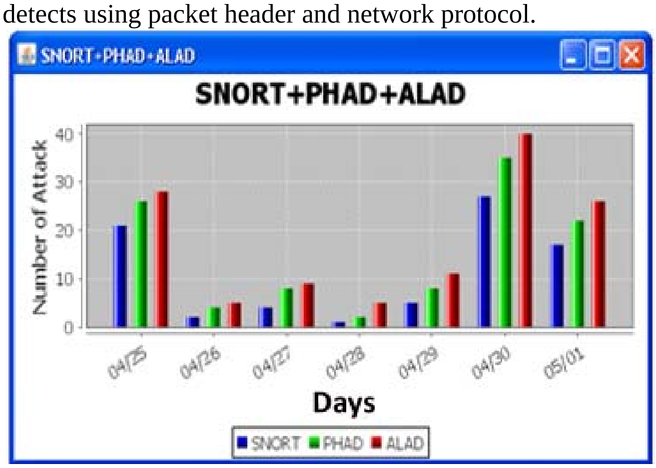

Figure 4. Attacks detected by Snort+PHAD+ALAD on a daily basis

D. Proposed Hybrid IDS (Snort+ALAD+LERAD)

Attacks detected by Snort, ALAD + LERAD on their own and results in the hybrid intrusion detection system (Snort + ALAD + LERAD) are shown in fig 5. After adding Snort+ALAD+LERAD, the ids give better results when compare with other methods. The number of attacks detected by Snort+PHAD+ALAD increase from 124 to 149 in Snort+ ALAD + LERAD (hybrid ids) version of the IDS.

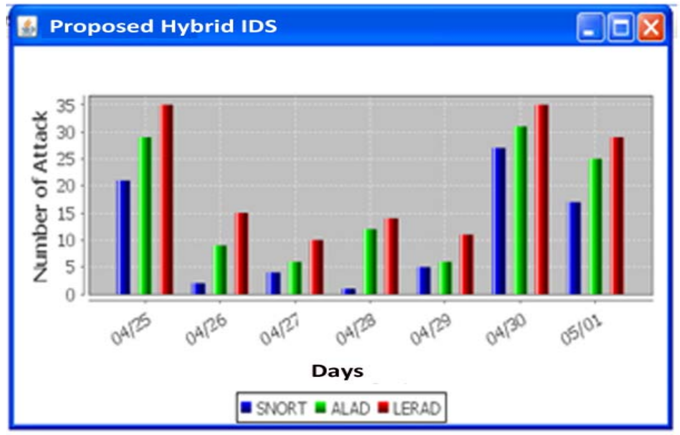

Figure 5. Attacks detected by Snort+ALAD+LERAD on a daily basis

Table 2. Attacks detected by Snort, PHAD, ALAD, and LERAD

Anomaly based approach	**Detection Rate**
Snort	77/180(43%)
Snort+PHAD	105/180(58%)
Snort+PHAD+ALAD	124/180(68%)
Proposed Hybrid IDS (Snort+ALAD+LERAD)	**149/180(83%)**

VIII. CONCLUSION & FUTURE SCOPE

For the past twenty years, several researches have been made in intrusion detection field. The overall aim is to develop a hybrid automatic intrusion detection system and thereby reducing the workload of the security experts. One of the major issues regarding human intervention in preprocessing is solved by implementing Snort with anomaly based approaches like Snort, PHAD ALAD, and LERAD. In this, Snort detects 43% of attacks, Snort+PHAD detects 58% of attacks, Snort+PHAD+ALAD detects 68% of attacks and our proposed hybrid IDS (Snort+ALAD+LERAD) detects 83% of attacks as seen from above figures.

In future, another hybrid detection model can be developed to detect the compromised system in the network which makes detection process fast and reliable.

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Location Anonymity schemes, Intrusion detection and prevention techniques, Cryptography, encryption algorithms and Key management schemes, Secure routing schemes, Secure neighbor discovery and localization, Trust establishment and maintenance, Confidentiality and data integrity, Security architectures, deployments and solutions, Emerging threats to cloud-based services, Security model for new services, Cloud-aware web service security, Information hiding in Cloud Computing, Securing distributed data storage in cloud, Security, privacy and trust in mobile computing systems and applications, **Middleware security & Security features:** middleware software is an asset on
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This Track will emphasize the design, implementation, management and applications of computer communications, networks and services. Topics of mostly theoretical nature are also welcome, provided there is clear practical potential in applying the results of such work.

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